BLACK GHOSTS OF THE FOREST
A UTAH BLACK BEAR STUDY

2008

Jordan C. Pederson

Steven B. Bates

Jerran T. Flinders

Abstract – The American black bear (Ursus americanus) of north central Utah occupies a habitat used for livestock grazing, logging, heavy recreational uses and human habitation. We began this study in 1985 to determine the food habits, habitat use patterns, home range sizes, productivity and general health of this population. Grasses and forbs provided the bulk of the spring diets and had an overall importance value of 47.2%. Animal matter was also a major component at 32.9%. Litter size averaged 1.7 cubs per adult female during the 10 years of this study. Home range sizes for males and females were 113 km^2 and 42 km^2 respectively. Five subadult males dispersed from our study area over distance ranging from 20-91 km; all were dead within three years. Management recommendations to ensure the population of this species so close to a major human population center are provided.

Key words: black bear, Ursus americanus, Utah, habitat, dispersal, food habits, home range.

HOME RANGE, HABITAT SELECTION, FOOD HABITS AND MOVEMENT PATTERNS OF NORTH CENTRAL UTAH BLACK BEARS

The American black bear (*Ursus americanus*) is faced with maintaining itself in a shrinking habitat base. Habitat loss has a subtle, yet permanent, impact on the long-term viability of bear populations (Beecham and Rohlman 1994). Increased interest in hunting bears (Figure 7) and cervids, recreational use and domestic livestock grazing are increasing pressure on the Hobble Creek – Diamond Fork (HC-DF) bear population. Knowledge of bear habitat relationships is needed to design habitat management systems which conserve and enhance black bear habitat. The understanding of black bear population dynamics in central Utah, including knowledge of population responses to changes in food supply and harvesting will produce better informed management.

OBJECTIVES

Determine:

- Seasonal habitat selection and use
- Movement patterns
- Home range and dispersal
- Den site characteristics
- Den behavior
- Mortality

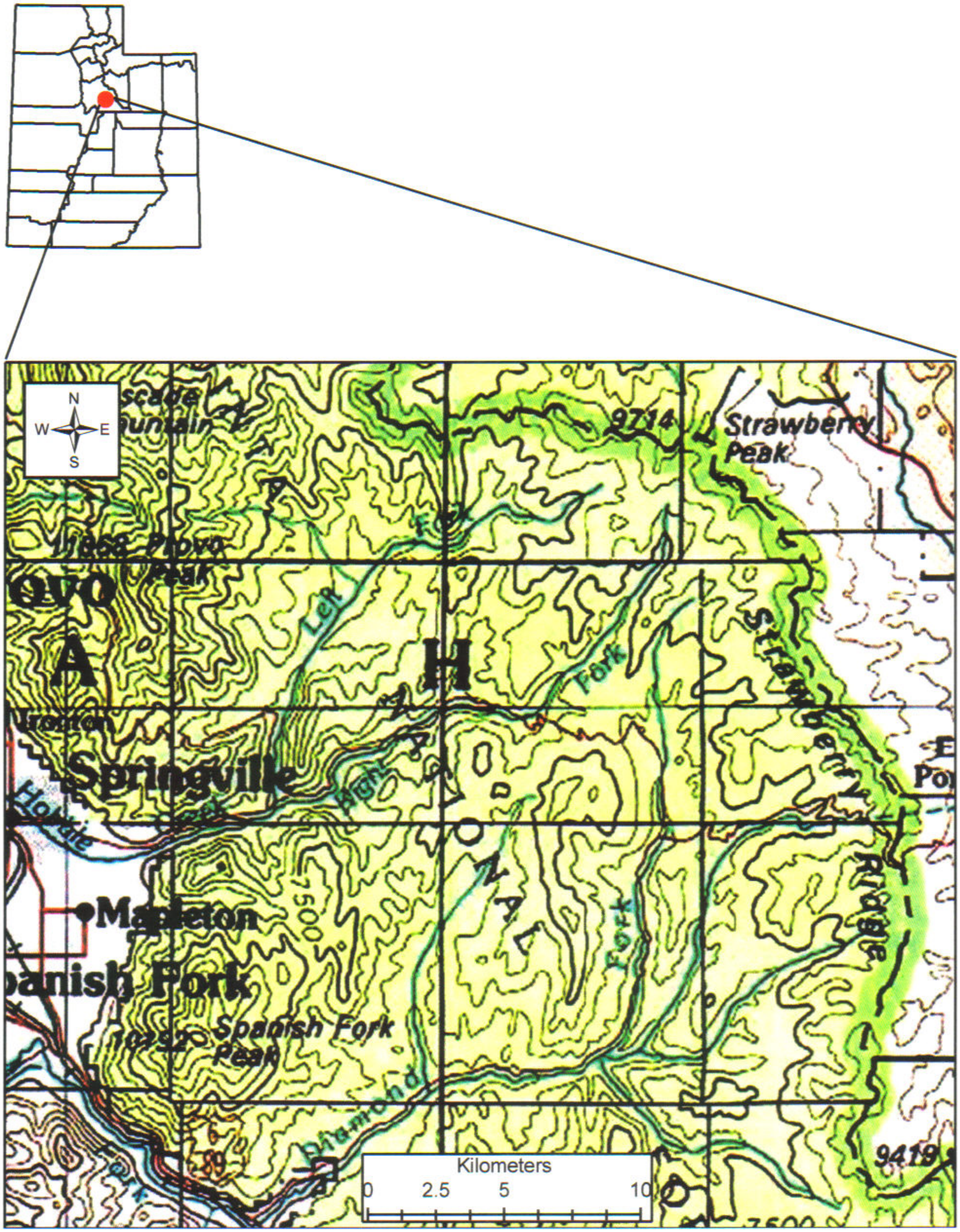
STUDY AREA

This study was conducted in the Hobble Creek and Diamond Fork drainages east of Springville, Utah County, Utah (Figure 1). Elevations range from 1,398 m to over 3,065 m, and the area encompasses approximately 1,225 km^2. Shale and sandstone are the primary rock formations. The climate is characterized by hot, dry summers and cold, wet winters. Annual precipitation ranges from 38.8 cm in Springville to over 52 cm on the highest ridges. Daily temperatures at Springville (elevation 1,398 m) vary between -30° and 40° C.

The higher elevations of the study site are dominated by aspen (*Populus tremuloides)*, and on the more mesic slopes, Engelmann spruce (*Picea engelmannii*), white fir (*Abies concolor*), subalpine fir (*Abies lasiocarpa*), and Douglas fir (*Pseudotsuga menziesii*). The middle and lower elevations are characterized by interspersions of Gambel oak (*Quercus gambelii*), bigtoothed maple (*Acer grandidentatum*), big sagebrush (*Artemesia tridentata*), and perennial grasses and forbs.

Limited commercial timber harvest was permitted prior to 1980, and regulated firewood harvest has been allowed since 1980. Historically cattle and sheep grazed the area but this has been reduced to mostly summer grazing by cattle over most of the study area, although several bands of sheep do graze on the northern and eastern perimeters. Recreational use (hiking, camping, fishing and hunting) is high, especially during the summer and fall periods.

Figure 1. Hobble Creek – Diamond Fork study area.



METHODS

Capture and Handling

Bears were trapped in culvert traps and Aldrich spring-activated snares from 1985-1992. Bears were immobilized using intramuscular injections of a 2:1 ratio mixture of ketamine hydrochloride and xylazine hydrochloride mixture administered by means of a $C0_2$ pistol or jab stick at an estimated dosage of 2ml:1ml/45.36 kg. Each bear was tattooed with an identification number on the upper lip, and numbered aluminum tags were affixed in both ears. Standard weight and size measurements were recorded, and an upper or lower first premolar was extracted from each bear older than one year for cementum annuli age determination (Willey 1974).

All females and selected males over two years of age were fitted with tracking and mortality-sensing radio collars (Telonics, Mesa, AZ). We monitored bears' movements from 1985 through 1994. Aerial telemetric observations were made on a 10-14 day interval as weather and flight schedules permitted. Visual and ground radio locations were obtained using triangulation March through November three times a week as conditions permitted. Locations were categorized by sex and season. Based on shifts in the diet, seasons were defined as follows: spring – den emergence to June 15, summer – June 16 to August 15, and fall – August 16 to den entrance (Bates 1991). Trapping was conducted May – August, 1985 to 1992.

Home Range Analysis

Detailed ground tracking of bears began in 1987 and continued through 1994. Sufficient locations were obtained from 15 radio-collared bears to calculate home range estimates. All ground black bear locations were plotted on U.S. Geological Survey 7.5-minute maps, and converted to UTM (Universal Transverse Mercator) coordinates. Aerial locations were plotted using an aircraft-mounted Loran Navigational System. Annual home range estimates were obtained by using the 95% Convex Polygon method (Bowen 1982, Onorato *et al*. 2003, Collins *et al*. 2005). Calculations were made by using a computer program designed by Ackermen *et al*. (1989). A minimum of 10 aerial locations were used to calculate home range size.

Habitat Analysis

On the ground, bears were approached until visual observation occurred or sign of fresh activity was found (i.e. tracks, scat, turned logs etc.). Micro-habitat plots (10 m x 10 m) associated with bear locations were described using Daubenmire's (1959) method for estimating canopy cover. Each plant species was identified, and percent cover, mean height, and phenological development were recorded. Macro-habitat data, within 500 m of mapped coordinates of bear locations, were also recorded (i.e. distance to water, distance to road, edge type, etc.). Horizontal obscurity cover was measured by the use of a density panel similar to the method described by Gysel and Lyon (1980). A 1 m x 1 m panel was placed at the centers of the 10 m x 10 m plots. The number of squares (total of 36) that were partially or completely obstructed by vegetation was recorded. Measurements were taken in the cardinal directions at 10 m and 20 m. The observer's line of sight was approximately 1 m above ground level. Percent obscurity was determined from these data.

Habitat availability was determined by overlaying Mylar sheets onto aerial photos. Conifer, conifer-aspen, aspen, riparian and "other" vegetative associations were delineated. The area from each association was grouped and weighed. The percent contributed by each association was calculated.

Data analyses were performed using chi-square, Mann-Whitney, and Kruskal-Wallis statistical tests (Conover 1980). Chi-square was used to compare the use of habitat types compared to their availability for all bear locations. The Mann-Whitney test assessed differences in the use of selected habitat variables; comparisons included comparing male versus random, female versus random, and male versus female. Seasonal use of habitat variables for males and females was evaluated using a Kruskal-Wallis test. All analyses were conducted using the System for Statistics (SYSTAT) computer software program (Wilkinson 1988).

Scat Collection and Testing

Black bear scat was collected opportunistically whenever encountered. Date, habitat type, and location were recorded for each scat. Samples were oven-dried at 60° for 48 hours prior to being analyzed.

A crude scat analysis was performed using procedures similar to those described by Tisch (1961) and Hatler (1972). Five general food categories were established: green vegetation, fruit, ants, other insects, and animal matter. Scats were first fragmented, and then food items were given a percent of volume rating.

A second analysis was conducted according to procedures used by Green and Flinders (1981) and O'Neal *et al*. (1987). Scats analyzed by the previous method were machine-washed in nylon sacks and rinsed until the waste water was clear. They were then dried in a clothes dryer. Each scat was spread out in a 25 cm x 25 cm gridded pan which allowed for the use of a random numbers table regarding points where items were identified. Food items were identified at twenty-five random points with each scat analyzed. The percent frequency of each dietary item was recorded, and after this, all food items were given a percent of volume rating by ocular estimation. Reference plant, hair, and seed collections were used for the identification of material in diets.

A Mann-Whitney test was performed to detect significance of the difference between the two methods of scat analysis. A Kruskal-Wallis test was conducted to test for significance between seasons within each food category.

Scat analysis results were tabulated by percent frequency of occurrence, percent volume, and percent importance value, where:

Frequency = Number of scats having the same item

$$\text{Percent Frequency of Occurrence} = \frac{\text{Frequency of forage item x 100}}{\text{Total number of scats}} \quad \text{x } 100$$

$$\text{Percent Volume} = \frac{\text{Total percent volume of forage item}}{\text{Total number of scats}}$$

$$\text{Importance Value} = \frac{\text{Percent volume x percent frequency of forage item}}{100}$$

$$\text{Percent Importance Value} = \frac{\text{Importance value of forage item x 100}}{\text{Sum of all importance values (IV1 + IV2 + IVN)}}$$

A Pearson's correlation matrix was computed from the means of each food category. These data were analyzed with Principle Components Analysis using the (SYSTAT) computer software program (Wilkinson 1988). The Eigen values are reported.

Fruit Collection and Testing

Eleven of the most common fruit bearing plants found on the study area were selected for nutrient analysis: red elderberry (*Sambucus racemosa*), common elderberry (*Sambucus caerulea*), thimble berry (*Rubus parviflorus*), snowberry (*Symphoricarpos oreophilus*), Oregon grape (*Mahonia repens*), red-osier dogwood (*Cornus sericea*), Woods rose (*Rosa woodsii*), mountain ash (*Sorbus scopulina*), chokecherry (*Prunus virginiana*), serviceberry (*Amelanchier alnifolia*), and Gambel oak.

Fruit was collected for each of the previously mentioned species on 1 m^2 plots randomly located across the study area. Branches within the plots were randomized and all fruit was collected from a randomly selected branch. A wet weight for the fruits was obtained using field scales.

In the laboratory, samples were oven dried for five days at 69 °C. Dry weights were taken and entire fruits ground and filtered through a #20 mesh screen. Seeds were removed from chokecherry prior to grinding. Samples were then analyzed for micronutrient content (Horwitz 1980).

Aging

Each bear trapped or denned was field aged as a cub of the year (COY), yearling, subadult or adult. Age grouping as described by Beck (1991): COY, 0-15 months; yearling, 16-26 months; subadult, 27-50 months and adult, 51+ months. One premolar was extracted using a dental elevator to be sure to obtain the root. These were sent to Matson's Laboratory in Milltown, Montana, for estimated age by cementum annuli analysis (Willey 1974). Field aging provided agreement with cementum annuli age 80 percent of the time.

Radio Telemetry

Aerial telemetry flights were made every 7-10 days during times when bears were out of their dens from March through November and monthly from December to February. February flights were used to locate dens prior to spring denning activities. Dens were located using radio telemetry by ground and air. Researchers were transported into the general vicinity by snowmobiles and snowshoes were used to reach the den entrances.

During the 10 years of the study, 116 telemetry flights were flown. Each flight was about three hours, for a total of 348 hours. There were 548 aerial locations plotted. During the ten years of this study 25 different bears were instrumented (12 males and 13 females). Fifty-seven different radios were placed on study animals.

RESULTS

Capture and Handling

We handled 48 individual bears, 83 times (Table 1). Twenty-six initial captures were made using Aldrich spring-activated cable foot snares (55%). Culvert traps accounted for 9 initial captures (19%). One bear was treed and tranquilized (3%). Subsequent captures were made using Aldrich cable snares (17), culvert traps (4). One was treed and recaptured. A recapture was made using a net gun fired from a helicopter. Her radio collar was replaced; fourteen subadult or adult bears were visited in their dens, and most had their radio collars replaced. Eleven COY or yearlings (YRLG) were sexed, weighed, and marked at this time.

It took 6.4 trap days per first catch using culvert traps and 4.1 days per first capture using the cable snares. Both methods took an average of 3.75 trap days to produce a successful catch. In summary, culvert traps accounted for 13 catches (16%), cable snares 43 catches (52%), and other methods 2 catches (3%). Den work accounted for 24 encounters with study bears.

Beck (1991) states, “Trapping programs usually are considered effective when they start catching subadult females.” During the course of our trapping efforts seven subadult females were trapped; 19.4% of the initial captures. Initial culvert or snare captures accounted for 15 males (45%) and 18 females (55%), a ratio of 1.2 females per male. All non-den captures during the eight years of trapping showed 26 males (45%) and 32 females (55%) for a ratio of 1.23 females per male.

During our eight-year trapping effort, no major trap-related injuries were observed. Bears that sustained minor injuries were treated with intramuscular injections of antibiotic and the site was treated with a topical antibiotic.

All captured or denned bears were measured, sexed, aged and released at point of capture. Twenty-five bears (12 males, 13 females) were fitted with collars containing 150-152 MHz radio transmitters. Fifty-seven different radios were placed on study bears. During the ten years this study was undertaken 116 telemetry flights were flown. Each flight was about three hours for a total of 348 hours. There were 548 aerial locations plotted. Outer perimeter of each home range was determined by a minimum of 10 locations (Table 3). Mean home range size was determined for males, females, adults and subadults.

Table 1. Black bears captured and monitored on the Hobble Creek-Diamond Fork Study Area, 1985-1994.

Bear No.	Sex	Field Age*	Date first radioed or marked	First caught location	Status as of 4-1-95	Last Contact
1	M	A	06/05/85	Timber Mtn.	Illegal Kill	11/85
2	F	A	06/15/85	Timber Mtn.	Illegal Kill	09/88
3	F	A	08/21/85	Wardsworth Cyn	Cast Collar	05/91
4	M	SA	06/02/86	Wardsworth Cyn	Hunter Harvest	05/89
5	M	SA	08/21/85	Wardsworth Cyn	ADC Bear RV, WY	05/06/88
6	M	A	07/10/86	Timber Mtn.	ADC Kill	09/90
7	F	A	07/11/86	Timber Mtn.	Natural Mort	05/15/89
8	M	YRLG	03/31/87	Wardsworth Cyn (Den)	ADC Red Hole	05/30/88
9	M	SA	06/29/87	Timber Mtn.	Hit by car US6	08/03/87
10	M	A	09/18/87	Springville City	Lgl Hvst/Manti	06/09/88
11	M	YRLG	09/26/87	Covered Bridge Cy	Ill Kill/Main Cyn	11/87
12	M	COY	03/15/88	RF Hobble Cr (Den)	Unknown	
13	M	YLRG	05/06/88	Shingle Mill Ridg.	Cast Collar	10/04/88
14	F	YRLG	06/07/88	Timber Mtn.	Radio quit	03/09/85
15	M	YRLG	06/17/88	Green Swales	Unknown	09/06/88
16	M	YRLG	07/22/88	Maple Canyon	Unknown	09/15/89
17	F	A	08/06/88	Fairview	Illegal Kill	09/06/88
18	F	COY	03/20/89	Wardsworth	Unknown	
19	F	COY	03/20/89	Wardsworth	Unknown	
20	M	COY	12/01/89	Cub of #7 (Mort) Placed in den	Unknown	04/15/90
21	F	COY	12/01/89	Placed in den in Red Hollow	Nat. Cause	04/15/90
22	M	SA	05/29/89	5th Water	Illegal Kill	07/17/90
23	F	A	06/14/89	2-Tom Hill	Nat. Mort	07/90
24	M	YRLG	06/20/89	Timber Mtn.	Cast Collar	07/90
25	F	A	07/07/89	Days Canyon	Cast Collar	09/09/91
26	M	SA	08/04/88	Pumphouse Ridge	Radio quit	06/07/91
27	F	A	08/01/89	LF Hobble Cr	Unknown	
28	M	COY	03/01/90	4th Water (Den)	Unknown	
29	M	COY	03/01/90	4th Water (Den)	Unknown	
30	F	COY	12/07/91	RF Hobble Cr (Den)	Cast Collar	07/20/90
31	F	COY	12/07/89	RF Hobble Cr (Den)	Unknown	
32	F	A	06/26/90	6th Water	Cast Collar	09/28/91
33	F	A	06/26/90	Maple Canyon	Legal Hunter Harvest on Study Area	09/18/94
34	M	YRLG	06/26/90	Shingle Mill	Alive (no radio)	
35	M	COY	03/18/91	Tie Fork (Den)	Cub of #32 unknown	
36	F	A	06/20/91	Timber Knoll	Legal Hunter Harvest	06/02/92
37	F	A	07/08/91	Green Swales	Unknown (no radio)	
38	F	COY	07/08/91	Wardsworth Cyn (Den)	Unknown (no radio)	
39	F	A	07/08/91	Timber Mtn.	Unknown	

40	F	A	08/20/91	Days Canyon	Unknown	
41	F	SA	08/20/91	Maple Canyon	Unknown	06/23/92
42	M	A	08/21/91	Days Canyon	Unknown	
43	F	A	06/10/92	Maple Canyon	Radio removed	03/11/94
44	M	A	06/12/92	Days Canyon	Unknown	
45	M	YRLG	08/05/92	Pumphouse Ridge	ADC Kill	09/94
46	M	SA	08/05/92	Whiting Cyn C.G.	Unknown (no radio)	
47	F	A	08/17/92	Pine Hollow	Depredation Kill by Cabin owner	
48	M	COY	03/01/90	4^{th} Water (Den)	Unknown	

Summary as of April, 1994

	N	%
Illegal Kills	5	10
Legal Kills (Hunting)	3	6
Natural Mortality	3	6
Accidents (hit by car)	1	2
Depredation (ADC & Private)	5	10
Unknown	31	66
Total	48	100

Table 2. Minimum home ranges of four adult male and eleven adult female black bears on the Hobble Creek – Diamond Fork study from 1987 – 1994 as determined by aerial telemetry.

Home Range Locations Bear #	Number of locations used to determine home range size.	Home range size km^2
M-5	17	1,024
M-6	21	460
M-13	10	22
M-26	24	414
F-2	16	66
F-3	13	74
F-7	21	464
F-14	21	144
F-23	14	89
F-25	22	176
F-32	18	91
F-33	16	40
F-36	14	73
F-39	14	118
F-43	15	21

Table 3. Mean home range size (km^2) for male and female black bears observed on study areas across North America.

		Home range km^2	
Source	Location	Males	Females
Alt el al. (1980)	Pennsylvania	173	41
Anstrup/Beecham (1976)	Idaho	112	49
Garshelis/Pelton (1981)	Tennessee	42	15
LeCount (1980)	Arizona	29	18
Lindzey/Meslow (1977)	Washington	5	2
LaSal Mts. (Tenney, 1996)	Utah	121	37
Book Cliffs (Tenney, 1996)	Utah	345	152
HC-DFSA THIS STUDY	Utah	113	42

Table 3. Mean home range size[1] (km^2) for two age classes of male and female black bears on the Hobble Creek – Diamond Fork study area from 1987-1989.

Bears			Home range km^2	
Class	No.	No. of locations	Mean	Range
Adult male	3	28	112.7	71.8 – 153.5
Adult female	5	212	41.4	16.2 – 60.0
Subadult male	3	55	43.0	10.0 – 76.2
Subadult female	1	33	28.9	28.9

[1]Determined by the 95% Convex Polygon method.

Home Range and Dispersal

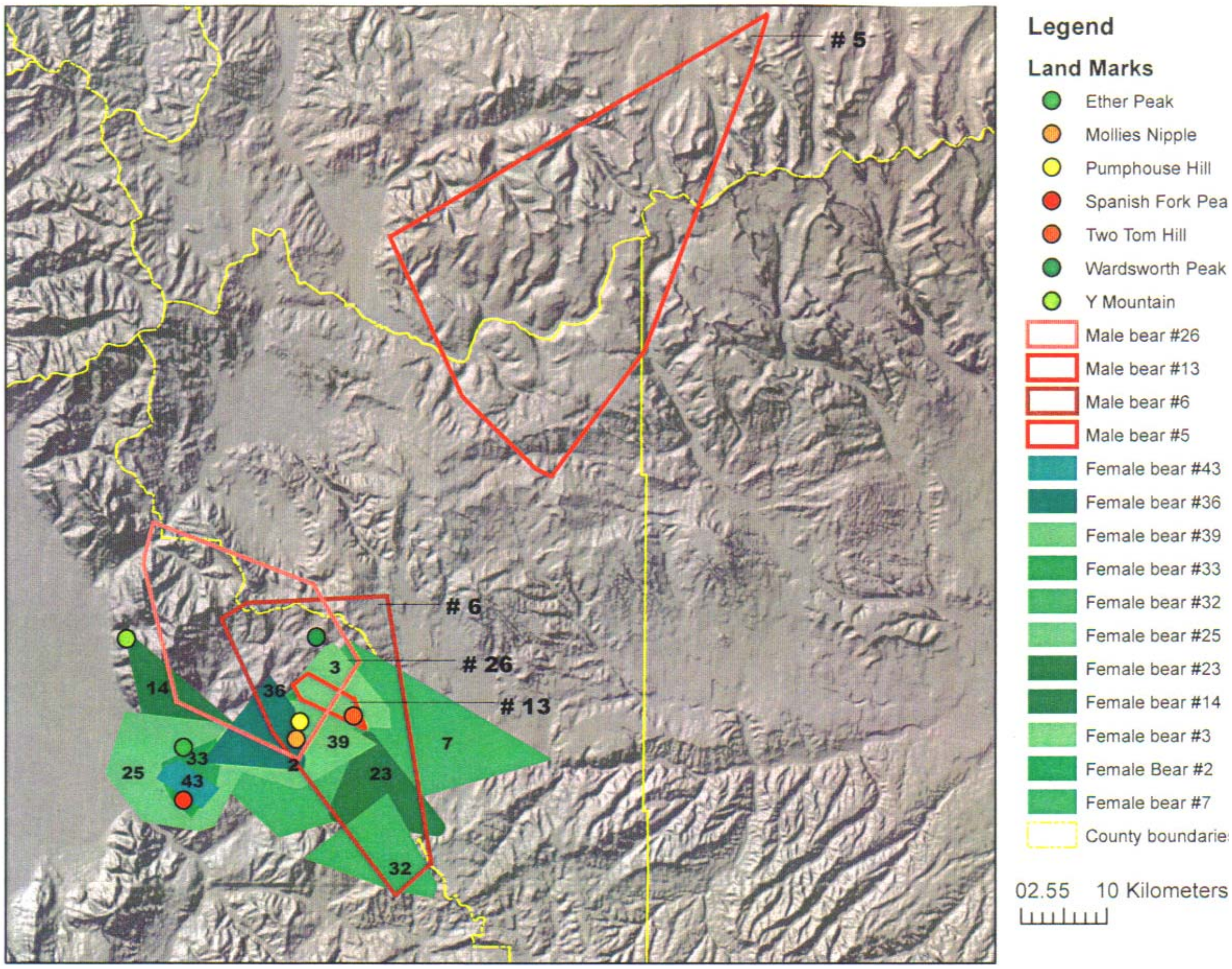
Sizes of black bear home ranges vary across their geographical distribution (Table 3). In the Hobble Creek-Diamond Fork Study Area (HC-DFSA), adult male home ranges (x = 112.7km^2) were approximately three times as large as adult female home ranges (x = 41.4 km^2).

The dispersal of subadult males was high; six of nine (67%) dispersed as yearlings, and the remaining three shed their collars by early spring of their second year (Figure 2). None of these males were caught in subsequent trapping efforts. One subadult female (14F) was monitored during the study. Following family break-up, she established a home range within the western edge of her mother's home range. In 1988 she used a 9 km^2 area, and the following year she doubled her range to 18 km^2.

<u>Movement of Subadult Males:</u> As represented in Figure 3, during this study five subadult males were trapped and instrumented. All moved off the HC-DFSA, and the general direction of travel was north and east. They were all dead within 18 months of moving to a new location. Three of these bears were killed by Animal Damage Control (ADC) agents actions, and one was killed by a hunter. Male 4 was killed by a legal bear hunter on Tabby Mountain, Duchesne County, Utah, and had moved 84 km.

Male 8 migrated to the Weber Drainage, Summit County, Utah, 70 km north. He was a frequent problem in a summer home area. He was live-trapped and moved back to the HC-DFSA near his birth den. Three weeks later we located him back in the Weber drainage high on the cliffs above Smith and Morehouse Reservoir. He spent the winter denned in that location, and when he emerged from his den he traveled 16 km north to an area known as the Red Hole. There he was killed by an ADC trapper during a livestock depredation incident June 30, 1988. He had moved a total distance of 86 km from the HC-DFSA.

Figure 2. Minimum home ranges of four adult male and eleven adult female black bears on the Hobble Creek – Diamond Fork study from 1987 – 1994 as determined by aerial telemetry.



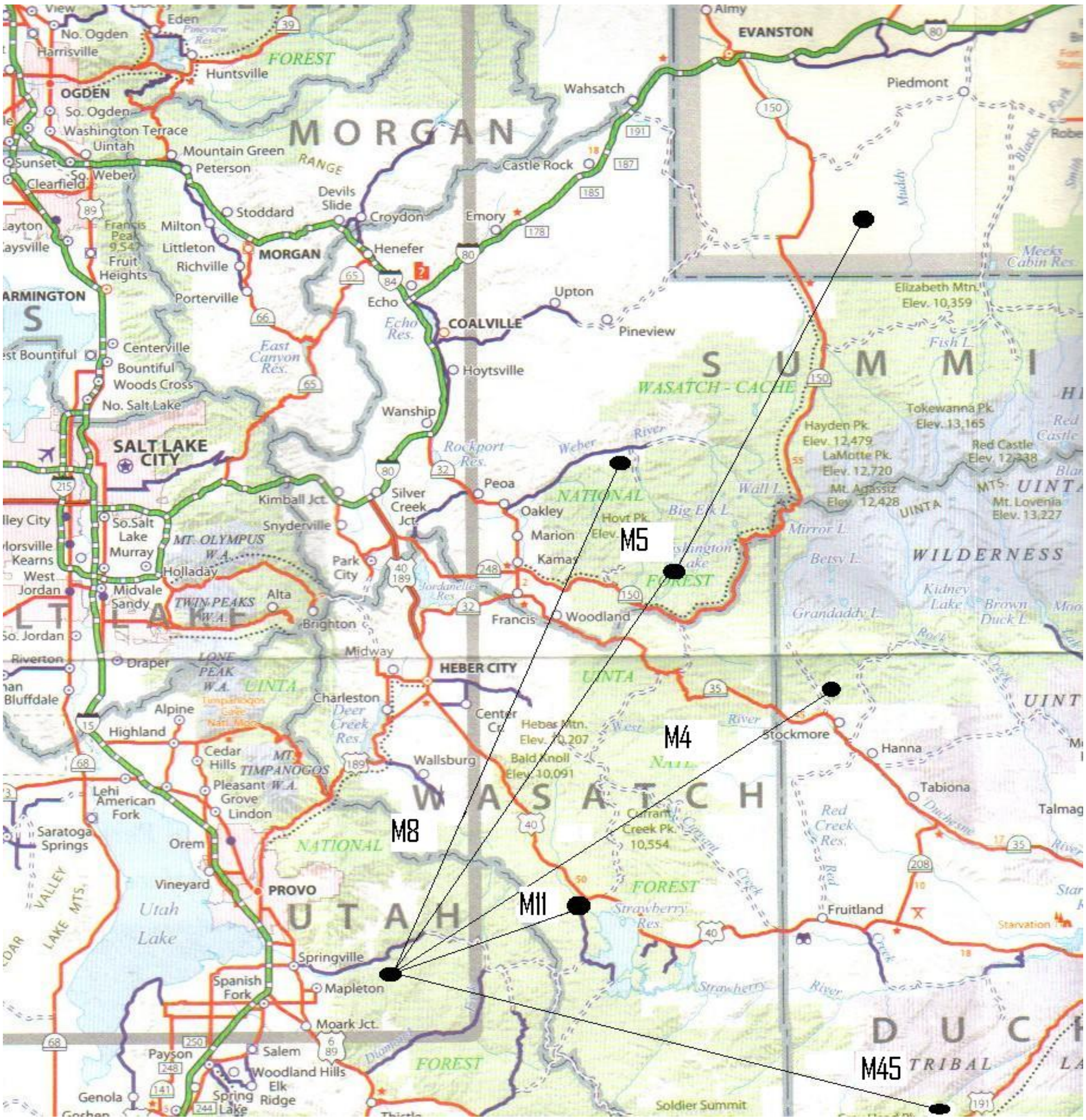
Male 5, a brother of M4, also migrated north and out of the HC-DFSA. He was radio tracked to Pine Valley, 7km east of Kamas. He was treed using dogs, tranquilized, and his radio collar was enlarged. He moved northeast to the north slope of the Uinta Mountains where he dug a winter den. On May 6,1988 he was killed by an ADC agent after killing several sheep on private property near Lone Mountain, Uinta County, Wyoming, on the Bear River Drainage. This was a straight-line movement of 91 km.

Subadult M11 moved northeast to Main Canyon, Wasatch County, Utah, in late fall 1987. His radio went into slow beat mode and he appeared to have denned in that area. In March 1988 we discovered him dead near Main Creek. Utah State Wildlife Resources law enforcement officers determined that he had been shot, probably in late fall of the preceding year. He had moved approximately 30 km.

Male 45, another subadult born on the study area, was killed by an ADC agent during a sheep depredation incident. This was on the Right Fork of the White River, Wasatch County, a straight line distance movement of 75 km Figure 3.

Figure 3. Migration distances (km) of subadult male black bears from HC-DFSA trap sites or dens to point of last contact.

M4	Legal hunter harvest	Moved 84 km from capture site
M5	Livestock depredation – ADC kill	Moved 91 km from capture site
M8	Livestock depredation – ADC kill	Moved 86 km from capture site
M11	Illegal kill – shot and left	Moved 30 km from capture site
M45	Livestock depredation – ADC kill	Moved 72 km from capture site



Seasonal Habitat Selection

Black bears in our study were observed to use a variety of habitat types. Habitats were classified into 9 categories: riparian, aspen, conifer/aspen mix, conifer, oak, oak/maple mix, maple, chokecherry, and "other."

Riparian zones made up 5.4% of the study area while aspen comprised 16.8%, conifer/aspen mix 7.8%, and conifer 8.3%. The mountain brush zone included the oak, oak/maple, maple, and chokecherry habitats and accounted for about 42.8% of the vegetation cover on the area. "Other" habitat types, including sagebrush, pinyon/juniper, xeric grass types, and nonvegetated areas accounted for the remaining 18.9% (Table 4).

During the study, habitat descriptions were obtained at 328 bear locations. Of these locations, 105 were described on a microhabitat level (10 m x 10 m plot) and measurements on several associated microhabitat ($\leq$ 500 m) variables were also made. From all locations (n=328), bears were most frequently associated with aspen (32%) and conifer stands (26%) during spring (n=51). Aspen habitats continued to be important during summer accounting for 21.7% of bear locations (n=181). Use of conifer stands was relatively high at 23.4%. Bear association with oak habitats increased significantly (p = 0.001) from 4.0% in spring to 20.1% during summer and accounted for 31.5% of fall locations (n=96). Significant changes in seasonal habitat use of maple and chokecherry habitats were also noted(p = 0.066 and p = 0.083 respectively).

The 105 microsites (10 m x 10 m) sampled were representative of all locations. Data collection at microsites was concentrated during times when bears were actively foraging. During spring, green vegetation (grasses and forbs) was the most important food source (Figure 4). We observed bears frequently associated with aspen (48%) and bigtoothed maple (51%).

Microsites with aspen and maple overstories produced abundant grasses and forbs in early phenological development (Table 4).

Bears continued to associate with aspen and maple in early summer while green vegetation was still tender. As summer progressed, grasses and forbs matured and the bears shifted their diets to include ants, which provide protein. At the same time a shift from aspen and maple to oak brush habitat occurred. Ant colonies were commonly observed in oak brush habitats, and evidence of ant use by bears, such as rolled stones and logs, was frequently found as summer progressed. We observed that bears continued using oak brush habitats for the remainder of summer. The fruit of serviceberries, commonly associated with Gambel oak habitats, was eaten beginning in late summer.

Table 4. Relative seasonal use (%) of nine habitat types by black bears on the Hobble Cree-Diamond Fork study area from 1987 to 1989.

Cover type	Percent available	Spring (51)	Summer (181)	Fall (96)
Riparian	5.4	6.0	7.1	3.3
Aspen1	16.8	32.0+[a]	21.7	19.6
Conifer/aspen	7.8	8.0	12.5	12.0
Conifer	8.3	26.0+	23.4+	15.2
Mountain brush	42.8	28.0-	35.3	50.0
oak[1]		4.0	20.1	31.5
oak/maple		12.0	7.1	9.8
maple[1]		12.0	7.6	2.2
chokecherry[1]		0.0	0.5	6.5
"Other"[2]	18.9	0.0-	0.0-	0.0-

[a] A + indicates use > availability and – indicates use < availability ($\underline{p} \le 0.05$).
[1] Seasonal use of habitat type differed significantly (K-W/ $\underline{p} \le 0.05$).
[2] "Other" habitat types include sagebrush, pinion/juniper, and xeric grass types as well as nonvegetated areas.

Figure . Seasonal use of major food categories (relative %) by black bears in the Hobble Creek – Diamond Fork study area from 1985 to 1989.

Bear association with fruit-bearing shrubs increased during fall. Serviceberry occurred on 42.9% of the microsites sampled during fall, and chokecherry occurred on 46.6%. Fruits comprised approximately 30% of the bears' fall diets. Bear association with oak brush at microsites was low (28.6%).

Microsites selected by females supported a greater diversity of vegetation than did sites chosen by males. Shannon's Index of Diversity values were 3.8 for females and 2.9 for males (Ludwig and Reynolds 1988). Sedentary females made best use of their home ranges by selecting the most productive foraging areas. The more mobile males were able to secure their needs by visiting a greater number of less productivie sites within their larger home ranges.

Habitat types used during spring significantly departed from expected in relation to habitat availability (x^2 = 36.0, a = 0.05). Bears selected strongly for aspen stands and moderately for conifer; "other" habitat types were avoided. Summer movements produced similar results. Aspen and conifer were selected for, and the "other" types were selected against, departing significantly from expected (x^2 = 97.3, a = 0.05). The remaining types were selected in proportion to their availability. Fall movements were more random and all habitat types were thus used in greater proportion to their availability. A significant departure from expected (x^2 = 27.4, a = 0.05) was still detected in fall locations resulting from the avoidance of "other" habitats (Table 4).

Conifers provided important cover for bears during all seasons. In addition to the 105 microsites analyzed, 4 bed sites were analyzed. All bed sites occurred in conifer-dominated stands. In Idaho, Young and Beecham (1986) also found bears preferred timbered slopes for bedding. Mollohan (1987) concluded that bears in Arizona chose bedding habitat based on security factors. Conifer stands on our study area occurred mainly on northerly aspects. In addition to the security cover value of conifers, these sites may have provided a refuge from high daytime temperatures. A noticeable decline in conifer use occurred during fall. The decline may have resulted from an increase in the amount of time bears spent foraging.

Bears avoided "other" habitats. These habitats were typically dry sites with sparse vegetation. Food was more abundant in the mesic habitats. An optimal foraging strategy would have precluded the use of the less productive habitats. Overstory species were sparse or low growing in these areas. Lecount (1980) indicated that bears will use nonforested areas as long as sufficient shrub cover is present. Concealment cover was probably insufficient in "other" habitats and contributed to the avoidance of these areas.

Cover and Edge

Bears selected dense vegetation in all seasons and in all habitat types. Horizontal obscurity was measured at 10 m and 20 m distances from the center of the 10 m x 10 m plots associated with bear location (Table 5). Excluding the single male observation in spring, all other observations showed at least 90% concealment at 10 m. Ninety-six to 100% concealment at 20 m. Females selected denser cover in spring then in fall; at 10 m, females selected significantly denser vegetation than did males.

Bears selected feeding sites with shrub dominated understories (Tables 6-8). Shrub height in the understory ranged from 0.5 m to 3.5 m. In Arizona, LeCount *et al*. (1984) found that the structure of vegetation was the most important criterion in meeting cover requirements for black bears. They concluded that cover in the 0.3 m to 2.0 m height class was very important for bear survival. Our findings are consistent with theirs.

All 10 m x 10 m plots, associated with black bear locations, were within 500 m of an edge between 2 or more habitat types. Table 9 lists average distances of edges obtained from

Table 5. Average horizontal obscurity values (%) measured in the cardinal directions at two distances at locations of male and female black bears on the Hobble Creek-Diamond Fork study area from 1987 to 1989.

Season	10 meters		20 meters	
	Male	Female	Male	Female
Spring	70.1[4]	90.0[112]	100.0[4]	97.1[112]
Summer	97.4[64]	95.8[156]	99.5[64]	99.3[156]
Fall	91.4[24a]	98.2[60]	96.3[24]	99.8[60]

[a]Indicated mean percent obscurity was lower for males than for females at 10 m during fall ($\underline{p} \leq 0.05$).
Superscript indicates sample size.

Table 6. The most frequently occurring plants located on spring microsites associated with black bear locations on the Hobble Creek-Diamond Fork study area from 1987 to 1989.

	frequency (%)	cover (%)	x height vertical (m)	phenophase
TREES				
Abies concolor	32.3	21.8	10.6	prereprod.
Acer grandidentatum	61.3	21.6	3.0	prereprod.
Populus tremuloides	48.4	32.8	6.2	fruit
SHRUBS				
Amelanchier alnifolia	51.6	14.1	1.3	flower
Rosa woodsii	41.9	2.5	0.6	prereprod.
Prunus virginiana	41.9	19.0	1.5	prereprod.
Symphoricarpos oreophilius	93.5	21.9	0.8	prereprod.
GRASSES				
Bromus carinatus	54.8	13.2	0.3	prereprod.
Poa fendleriana	48.4	10.7	.02	prereprod.
FORBS				
Achillea millefolium	51.6	4.1	0.1	prereprod.
Galium boreale	61.3	10.3	0.1	flower
Hydrophyllum capitatum	74.2	7.4	0.1	flower
Stellaria jamesiana	80.6	5.0	0.1	flower

Table 7. The most frequently occurring plants located on summer microsites associated with black bear locations on the Hobble Creek-Diamond Fork study area from 1987 to 1989.

	frequency (%)	cover (%)	x height vertical (m)	phenophase
TREES				
Abies concolor	24.6	23.8	9.0	fruit
Acer grandidentatum	45.9	23.0	3.4	postreprod.
Populus tremuloides	42.6	25.0	5.4	postreprod.
SHRUBS				
Amelanchier alnifolia	44.3	13.9	1.8	fruit
Quercus gambelii	36.1	33.9	2.7	fruit
Symphoricarpos oreophilius	78.7	18.8	0.9	fruit
GRASSES				
Bromus carinatus	68.9	11.3	0.6	flower
Poa fendleriana	70.5	19.9	0.3	postreprod.
FORBS				
Lathyrus lanszwertii	50.8	5.7	0.5	flower
Osmorhiza chilensis	70.5	5.4	0.4	fruit
Stellaria jamesiana	50.8	4.9	0.1	flower

Table 8. The most frequently occurring plants located on fall microsites associated with black bear locations on the Hobble Creek-Diamond Fork study area from 1987 to 1989.

	frequency (%)	cover (%)	x height vertical (m)	phenophase
TREES				
Abies concolor	14.3	25.8	5.9	fruit
Acer grandidentatum	28.6	30.8	3.6	postreprod.
Populus tremuloides	42.9	40.8	5.4	postreprod.
SHRUBS				
Amelanchier alnifolia	42.9	17.5	2.1	fruit
Prunus virginiana	47.6	38.5	2.0	fruit
Quercus gambelii	28.6	41.7	3.3	postreprod.
Symphoricarpos oreophilius	81.0	22.2	0.9	fruit
GRASSES				
Bromus carinatus	81.0	14.1	0.7	fruit
Poa fendleriana	57.1	13.8	0.3	postreprod.
FORBS				
Achillea millefolium	47.6	2.5	0.1	postreprod.
Thalictrum fendleri	47.6	2.5	0.4	postreprod.

Table 9. Relative percent frequencies (%) and mean distances (≤ 500 m) to habitat edges for male and female black bear locations, by season, on the Hobble Creek-Diamond Fork study area from 1987 to 1989.

Season	Frequency (%)		Distance (< 500 m)	
	male	female	male	female
Spring	100.0^{1}	100.0^{28}	50.0	52.5
Summer	100.0^{16}	100.0^{39}	50.1	62.3
Fall	100.0^{6}	100.0^{15}	44.2	75.0

Superscript indicates sample size.

male and female locations. Generally both sexes associated with edges between 2 habitat types. Males showed slight preference for sharp edges (≤ 5 m) over ecotone edges (6m-20 m). Females showed a slight preference for ecotone type edges (Table 10).

Habitat edges benefit many wildlife species because of the diversity of transitional vegetation and its associated structure (Robinson and Bolen 1984). The frequency and close proximity to which bears we studied associated with edges demonstrated the importance of these zones for black bears. Lindzey and Meslow (1977) similarly noted the importance of edges to bears in Washington.

Elevation, Slope and Aspect

Both males and females showed similar patterns of elevational use; mean elevations decreased from spring levels (2295.1 m for males, 2236.3 m for females) to lower summer levels (2180.5 m for males, 2152.0 m for females). Mean elevations for both sexes increased again in fall to 2280.4 m for males and 2289.1 m for females. Elevational use did not differ significantly from average available elevation (2233.3 m) during any season (Table 11).

Female bears used progressively steeper slopes in spring (x = 26.7%). Excluding the single spring location, males showed a similar pattern in choosing steeper slopes in fall than in summer. Both sexes preferred steep slopes in fall when compared to mean slope availability (Table 12).

Both sexes chose slope aspects significantly different from expected during all seasons (Table 13). Northerly aspects were used most frequently by both sexes during spring (100% males, 60.7% females) and summer (75.1% males, 56.5% females). Males preferred easterly aspects in fall (33.3%) while females selected slopes with westerly aspects (46.7%). Both sexes avoided southern exposures during all seasons.

Table 10. Frequency of occurrence (%) for habitat edge types for male and female black bear locations on the Hobble Creek-Diamond Fork study area from 1987 to 1989.

Edge type	Spring		Summer		Fall	
	Male (1)	Female (28)	Male (16)	Female (39)	Male (6)	Female (15)
Riparian	0.0	3.6	0.0	0.0	0.0	0.0
(≤ 5 m)	0.0	50.0	50.0	43.6	50.0	40.0
(6-20 m)	100.0	46.4	31.3	48.7	33.3	53.3
3 habitats	0.0	0.0	18.8	2.6	16.7	0.0
>3 habitats	0.0	0.0	0.0	5.1	0.0	6.7

( ) indicates sample size.

Table 11. Mean elevation (m) of male and female black bear and random locations by season on the Hobble Creek-Diamond Fork study area from 1987 to 1989.

Season	Male	Female	Random
Spring	2295.1^{1}	2236.3^{28}	2233.3^{100}
Summer	2180.5^{16}	2152.0^{39}	2233.3^{100}
Fall	2280.4^{6}	2289.1^{15}	2233.3^{100}

Superscript indicates sample size.

Table 12. Mean slope (%) of male and female black bear locations by season on the Hobble Creek-Diamond Fork study area from 1987 to 1989.

Season	Male	Female
Spring	38.0^{1}	19.8^{28}
Summer	22.4^{16}	23.4^{39}
Fall	28.0^{6}	26.7^{15}

Superscript indicates sample size.

Table 13. Frequency of occurrences (%) for slope aspect for male and female black bear locations on the Hobble Creek-Diamond Fork study area from 1987 to 1989.

Aspect	Random	Spring		Summer		Fall	
		Male	Female	Male	Female	Male	Female
	(100)	(1)	(28)	(16)	(39)	(6)	(15)
N	13.0	0.0	35.7+[a]	37.5+	23.1+	16.7	13.3
NE	12.0	0.0	14.3	18.8	10.3	16.7	6.7
E	13.0	0.0	10.7	6.3	10.3	33.3+	6.7
SE	13.0	0.0	10.7	0.0-	7.7-	0.0-	6.7-
S	9.0	0.0	7.1	6.3	10.3	0.0-	0.0-
SW	13.0	0.0	3.6-	0.0-	10.3	0.0-	0.0-
W	14.0	0.0	7.1	12.5	5.1-	16.7	46.7+
NW	13.0	100.0	10.7	18.8	23.1+	16.7	6.7

[a]A + indicates use > expected and – indicates use < expected ($p \leq 0.10$).

The choice of elevation, slope inclination aspect by bears appears to have been determined largely by diet. Bears seasonally frequented elevations, slopes, and aspects that supported habitats which produced the greatest foraging opportunities. Bears in southeastern Utah used aspects and made elevational movements similar to those we observed for bears in our study area (Richardson 1991). Similar site selection by black bears in relation to slope and elevation also has been observed on other mountainous study areas as well (Garshelis and Pelton 1980, Greer 1987, Mack 1988).

Aside from females with cubs and breeding pairs, black bears are solitary animals and exhibit special-temporal spacing (Pelton 1982). LeCount *et al*. (1984) found that male and female black bears used similar elevations during spring and fall. However, a separation in habitat use was observed. Males used gentler slopes than females. In summer, a separation of male and female black bears in Arizona was achieved by differences in elevational use. Bears we observed used similar elevations and slopes during all seasons. Perhaps home ranges of bears in our study were sufficiently large to alleviate the need for sexes to segregate by means of slope or elevation.

During fall, we found that both sexes and all ages of bears used similar slopes and elevations during those periods when fruits occurred in localized areas. Competition between sexes at these patches may have been avoided by males selecting east aspect slopes and females using west aspect slopes.

Distance to Water (< 500 m)

During spring, both males and females were frequently found within 500 m of a creek (100% and 92.9%, respectively). Females also were significantly closer than expected (p = 0.001) from an assessment of random points. Females continued to use habitats in close proximity to creeks throughout the summer (71.8%). Statistically, neither sex demonstrated an attraction to or an avoidance of creeks during fall (Table 14). Other water sources, including a few ponds, were scattered across the study area. Females used pond sites significantly more than expected ($p = 0.049$) during spring. Males demonstrated no preference for ponds at any season (Table 14).

In Idaho, Unsworth *et al*. (1989) indicated that riparian zones produced abundant foods and were frequently used as feeding sites. Young and Beecham (1986) also noted the importance of riparian habitats as feeding sites. The frequency and close proximity to creeks indicated likely use of riparian habitats.

Females were frequently found closer to water in both spring and summer. Females with cubs accounted for 70.7% of female locations (n = 82) described in conjunction with riparian microhabitat selection possibly to meet the demands of lactation.

Distance to Roads and Trails (< 500 m)

The study area was accessible by means of numerous dirt roads. Every black bear home range was bisected by at least one road. Table 15 shows the frequency and average distance that bear and random locations were observed within 500 m of a road. Females avoided roads in spring ($p = 0.109$), but neither avoided nor used habitats associated with roads different than expected in summer or fall. In spring males avoided roads as well. In summer and fall male selection of habitats appeared unaffected by the presence of roads.

With the exception of females in spring, bears associated with roads as often as would have been expected from random movement. However, mean distance from bear locations to roads exceeded 200 m. Bears in Michigan and North Carolina were observed using roads as travel corridors (Manville 1983, Beringer *et al*. 1989). We observed that bears cross roads directly and avoid long movements on them.

Table 14. Relative percent frequencies (%) and mean distances (≥ 500 m) to creeks for male and female black bear locations, by season, on the Hobble Creek-Diamond Fork study area from 1987 to 1989.

Season	frequency (%)			distance (≤ 500m)		
	male	female	random	male	female	random
Spring	100.0^{1}	92.9^{28}+[a]	51.0^{100}	420.0	250.6	178.9
Summer	38.8^{16}	71.8^{39}+	51.0^{100}	122.0+	196.3	178.9
Fall	66.7^{6}	66.7^{15}	51.0^{100}	153.8	284.0	178.9

[a] A + indicated > or nearer than expected ($p \le 0.10$).
Superscript indicated sample size.

Table 15. Relative percent frequencies (%) and mean distances ($\geq$ 500 m) to dirt roads for male and female black bear locations, by season, on the Hobble Creek-Diamond Fork study area from 1987 to 1989.

Season	frequency (%)			distance ($\leq$ 500m)		
	male	female	random	male	female	Random
Spring	100.0[1]	28.6[28]-[a]	40.0[100]	430.0	253.8	238.7
Summer	56.3[16]	41.0[39]	40.0[100]	202.2	202.5	238.7
Fall	66.7[6]	40.0[15]	40.0[100]	212.5	286.7	238.7

[a] A - indicated use > expected ($p \leq 0.10$).
Superscript indicated sample size.

While studying grizzly bears (*Ursus arctos*) Zager (1980) hypothesized that females with cubs would avoid areas near roads more often than other bears. The limited use of spring habitats near roads by females in our study appears to support this hypothesis. In Alberta, Young and Ruff (1982) observed similar results.

Spring avoidance of roads by females may have resulted from high levels of elk and deer hunting activity on roadways during late fall. Female denning behavior coincided with Utah's general deer season in late October. Females may have selected denning sites where hunting pressure was lightest--away from roads. As a result, spring habitats were initially removed from roads. The limited mobility of cubs during spring may have minimized expansion of adult ranges to include habitats near roads. With increased cub mobility in summer and fall, females were found using habitats near roads in proportion to availability.

Several trails were maintained on the study area, however few people used them during spring. Horse riders and hikers were the main recreational user groups during spring and summer. Heaviest trail use occurred during fall by elk and deer hunters. In spring and summer bears used these trails and associated with trails less frequently during spring or summer (Table 16).

With light human traffic in the spring and summer, bears were able to utilize trails as travel corridors. Bears most likely used trails for quick access between foraging and bedding sites. Using trails would require less energy than movement through dense brush. High human use of trails during fall probably resulted in bears spending increased time and energy fleeing from danger. As a result, bears may have avoided areas with trails to minimize energy costs associated with human encounters.

Table 16. Relative percent frequencies (%) and mean distances ($\geq$ 500 m) to man made trails for male and female black bear locations, by season, on the Hobble Creek-Diamond Fork study area from 1987 to 1989.

Season	frequency (%)			distance ($\leq$ 500m)		
	male	female	random	male	female	random
Spring	100.0^{1+a}	35.7^{28}+	28.0^{100}	75.0	147.0	218.9
Summer	31.3^{16}	51.3^{39}+	28.0^{100}	156.0	117.7+	218.9
Fall	16.7^{6}	20.0^{15}	28.0^{100}	40.0+	163.3	218.9

[a] A + indicated use > or nearer than expected while – indicates use < expected ($\underline{p} \leq 0.10$). Superscript indicated sample size.

Distance to Ungulates (< 500 m)

Domestic livestock occurred on private land as well as on lands managed by the U.S. Forest Service. Leased acres were utilized by cattle, equating to 5,400 animal unit month's (AUM's), and these leases ran from June 10 to October 20. No sheep allotments occurred within the study area but several bands grazed the perimeters (Lienbach 1987). Bears were occasionally observed foraging within 500 m of cattle. Males were located near cattle more frequently than were females. The difference is not statistically significant ($p = 0.198$) (Table 17). Males also encountered sheep more frequently than did females when sheep trespassed into the study area (Table 18). Although no livestock predation by black bears was documented in the study area, several sheep were killed by bears in surrounding drainages (M. Tamolos, Wildlife Specialist, U.S. Dept. of Agriculture).

Comparatively more sedentary females made best use of their home ranges by selecting the most productive foraging areas. The more mobile males were able to secure their needs by visiting a greater number of less productive sites within their larger home ranges.

Habitat use in relation to availability supported data gathered from microhabitat sites. Aspen and conifer were the habitat types most often selected. Aspen provided important forage areas during all seasons but especially in the spring and early summer. Richardson (1991) reported similar spring habitat use by bears in southeastern Utah, i.e., black bears on the southeastern Utah study area selected aspen, conifer mix and conifer habitats. Likewise, Young and Ruff (1982) indicated that bears used aspen preferentially on their study area in Alberta, Canada. Aspen stands were reported to contain the greatest number of forage species used by black bears.

Table 17. Relative percent frequencies (%) and mean distances ($\geq$ 500 m) to cattle for male and female black bear locations, by season, on the Hobble Creek-Diamond Fork study area from 1987 to 1989.

Season	frequency (%)		distance ($\leq$ 500m)	
	male	female	male	female
Spring	0.0^{1}	17.9^{28}	--	213.0
Summer	31.3^{16}	23.1^{39}	315.0	286.7
Fall	83.3^{6}	46.7^{15}	127.0	201.4

Superscript indicated sample size.

Table 18. Relative percent frequencies (%) and mean distances (≥ 500 m) to stray sheep in the study for male and female black bear locations, by season, on the Hobble Creek-Diamond Fork study area from 1987 to 1989.

Season	frequency (%)		distance (≤ 500m)	
	male	female	male	female
Spring	100.0^{1}	0.0^{28}	420.0	--
Summer	6.3^{16}	5.1^{39}	400.0	175.0
Fall	16.7^{6}	0.0^{15}	400.0	--

Superscript indicated sample size.

In Idaho, Young and Beecham (1986) also found that bears preferred timbered slopes for bedding. Mollohan (1987) concluded that bears in Arizona chose bedding habitat based on security factors. Conifer stands on our study area occurred mainly on northerly aspects. In addition to the security cover values of conifers, these sites may have provided a refuge from high daytime temperatures. A noticeable decline in conifer use occurred during the fall. The decline may have resulted from an increase in the amount of time bears spent foraging.

Bears avoided “other” habitats, which were typically dry sites with sparse vegetation. Food was more abundant in the mesic habitats, and an optimal foraging strategy would have precluded the use of the less productive habitats. Overstory species were sparse or low growing in these areas. LeCount (1980) indicated that bears will use non-forested areas as long as sufficient shrub cover is present. Concealment cover was probably insufficient in “other” habitats, and contributed to the avoidance of these areas.

We found bears closely associated with deer, elk, or moose during all seasons, and evidence of black bear predation on cervids was observed in all seasons (Bates 1991) (Figure 4). Grenfell and Brody (1983) also documented deer in the diets of bears.

Bears have been shown by several researchers to be opportunistic feeders (Hatler 1972, Graber and White 1983, Greer 1987) and will feed upon native and domestic ungulates as opportunities present themselves (Hortsman and Gunson 1982, Grenfell and Brody 1983). We cannot say with certainty why bears in our study area pursued and consumed native ungulates while refraining from killing less elusive livestock that occurred on the same ranges. Many years of active removal of livestock-killing bears may have selected for bears not showing these tendencies. Bears in the study area also did not raid cabins or garbage cans, perhaps for the same reason.

Figure 4 . Frequency of occurrence for ungulates in the diets of black bears in the Hobble Creek–Diamond Fork study area. Ungulate remains were observed in 42 (23.5% of the 179 scats collected from 1985 to1989.

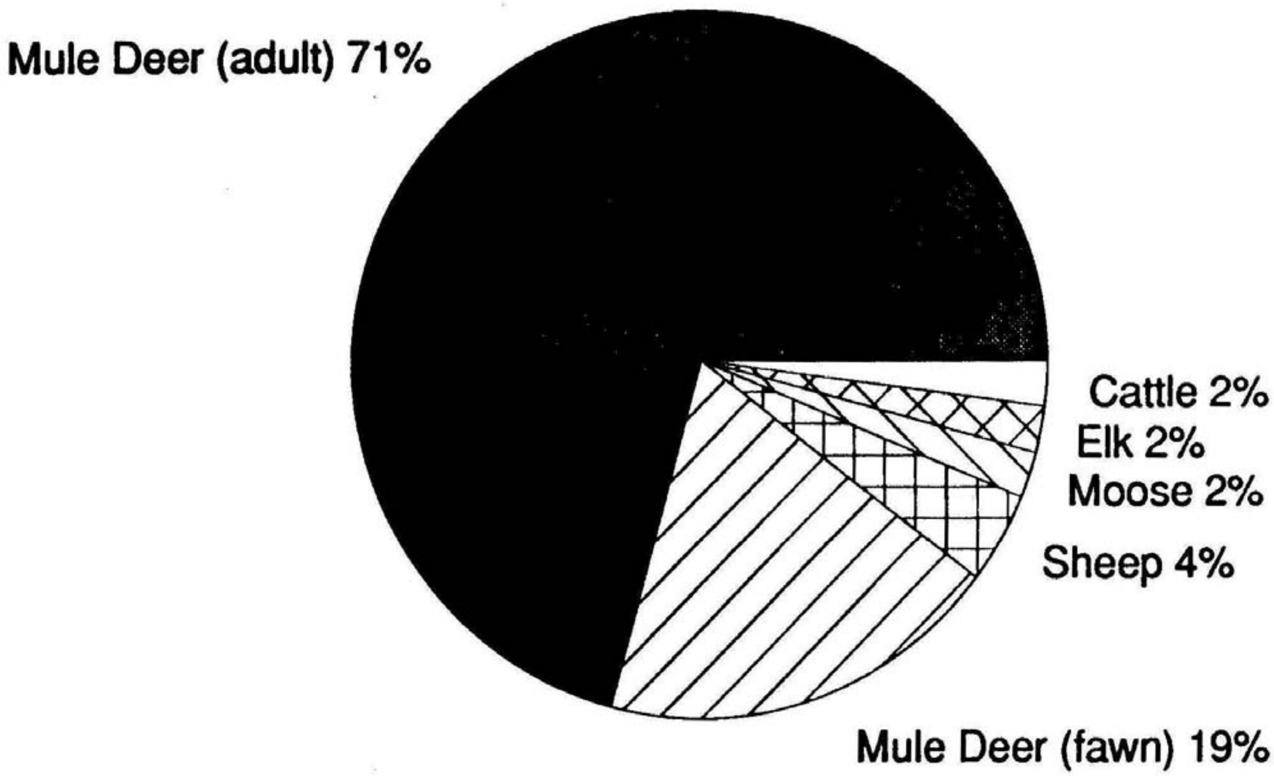


Figure 5. Seasonal use of animal matter (frequency of occurrence) by black bears in the Hobble Creek – Diamond Fork study area from 1985 to 1989.

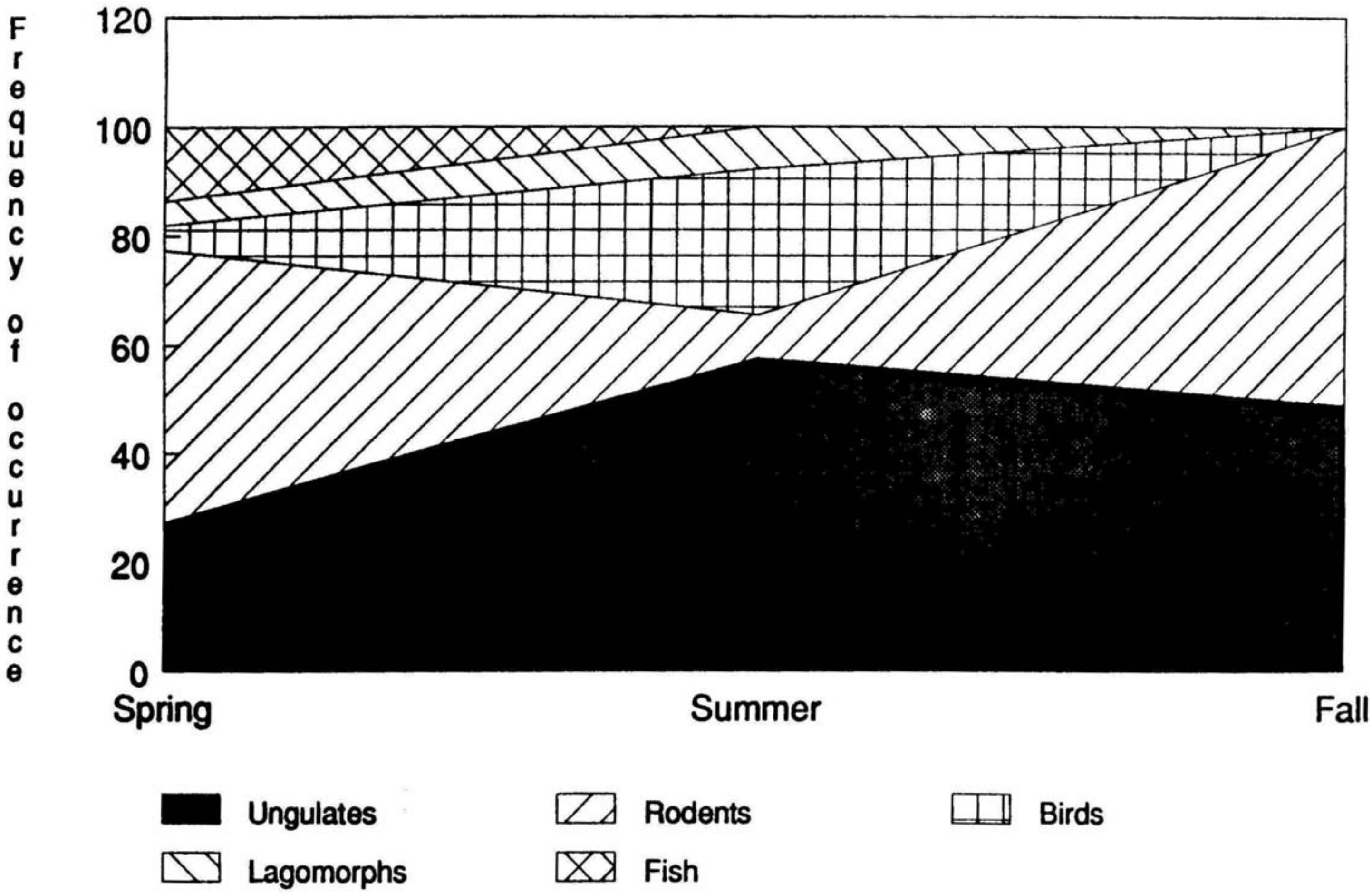
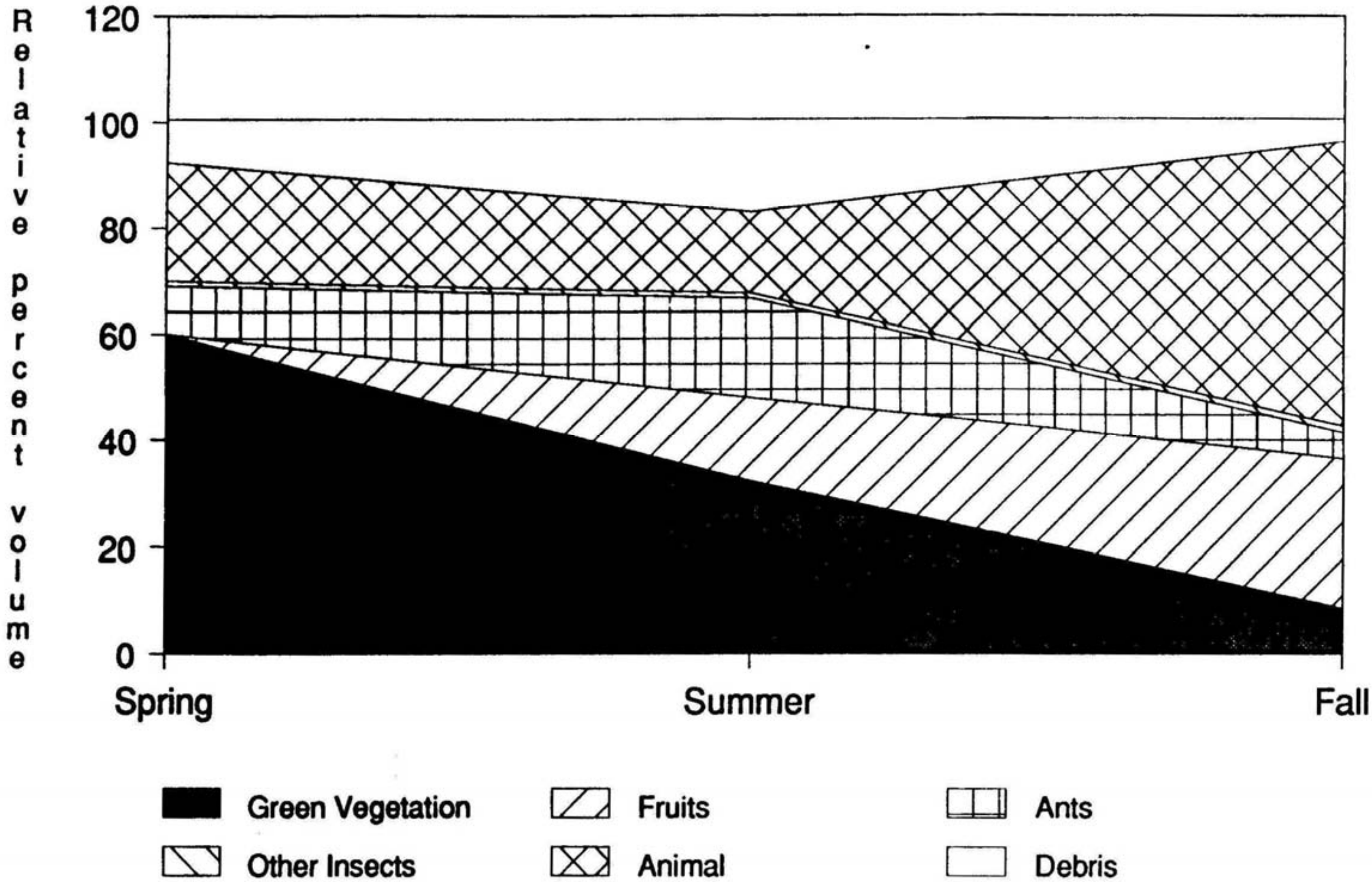


Figure 6. Seasonal use of major food categories (relative %) by black bears in the Hobble Creek – Diamond Fork study area from 1985 to 1989.



DISCUSSION

Home Range and Dispersal

Bears in our study had comparatively large home ranges. Jonkel and Cowan (1971), Armstrup and Beecham (1976), and LeCount (1980) suggested that the quality, quantity, and distribution of food set minimum sizes of bears' (particularly female's) home ranges, as influenced by climate and topography. Mack (1988) indicated that large home range size is indicative of low quality habitats. In Pennsylvania, Alt *et al*. (1980) found male black bears using large home ranges averaged 173 km^2 while females occupied smaller ranges of 72 km^2 (Table 19). At the other extreme, Lindzey and Meslow (1977) observed bears using very small home ranges on Long Island in southwestern Washington. Males used home ranges of 5 km^2, and females, 2 km^2.

Although bears in our study had large home ranges, they appeared to obtain adequate nutrition. This is evident by the large average size obtained by all age and sex classes of bears in our study (Table 20). One 3 year-old female produced 2 cubs in her first litter, which suggests that her nutritional needs were being met. According to Rogers (1976), early reproduction in bears ($x \leq 4$ years) is an indication of higher nutrition levels. Bears we studied were also effective predators (Figure 4 and 5). Perhaps the inclusion of animal prey in their diets required bears in our study to occupy large areas. Home range size data from eight black bear studies are summarized in Table 19 (Tenney 1996).

Bears of the same sex used nearly exclusive home ranges; common areas were shared at peripheries. However, considerable home range overlap occurred between males and females in our study (Figure 2). Similar results have also been reported by others (Armstrup and Beecham

Table 19. Mean home range size (km^2) for male and female black bears observed on study areas across North America.

		Home range km^2	
Source	Location	Males	Females
Alt el al. (1980)	Pennsylvania	173	41
Anstrup/Beecham (1976)	Idaho	112	49
Garshelis/Pelton (1981)	Tennessee	42	15
LeCount (1980)	Arizona	29	18
Lindzey/Meslow (1977)	Washington	5	2
LaSal Mts. (Tenney, 1996)	Utah	121	37
Book Cliffs (Tenney, 1996)	Utah	345	152
HC-DFSA THIS STUDY	Utah	113	42

Table 20. Mean black bear summer weights (kg), by age class, from four different studies.

	Subadult		Adult	
Study site	Male	Female	Male	Female
Montana	36.9	30.2	85.7	54.2
Massachusetts	41.8	28.6	104.0	63.0
Southeastern Utah	51.3	44.3	124.0	73.5
HC-DFSA	68.5	60.3	156.8	103.7

1976, Lindzey and Meslow 1977, LeCount *et al*. 1984). Rogers (1987) indicated that males attempt to maximize reproductive success by breeding with as many females as possible. This strategy would account for the high degree of intersexual overlap and large home ranges of males. Home range size data from eight black bear studies are summarized in Table 20.

Dispersal

<u>Movement of Subadult Males:</u> As represented in Figure 3, during this study five subadult males were trapped and instrumented. All moved off the HC-DFSA, and the general direction of travel was north and east. They were all dead within 18 months of moving to a new location. Three of these bears were killed by Animal Damage Control (ADC) agents actions, and one was killed by a hunter. Male 4 was killed by a legal bear hunter on Tabby Mountain, Duchesne County, Utah, and had moved 84 km.

Male 8 migrated to the Weber Drainage, Summit County, Utah, 70 km north. He was a frequent problem in a summer home area. He was live-trapped and moved back to the HC-DFSA near his birth den. Three weeks later we located him back in the Weber drainage high on the cliffs above Smith and Morehouse Reservoir. He spent the winter denned in that location, and when he emerged from his den he traveled 16 km north to an area known as the Red Hole. There he was killed by an ADC trapper during a livestock depredation incident June 30, 1988. He had moved a total distance of 86 km from the HC-DFSA.

Male 5, a brother of M4, also migrated north and out of the HC-DFSA. He was radio tracked to Pine Valley, 7km east of Kamas. He was treed using dogs, tranquilized, and his radio collar was enlarged. He moved northeast to the north slope of the Uinta Mountains where he dug a winter den. On May 6,1988 he was killed by an ADC agent after killing several sheep on private property near Lone Mountain, Uinta County, Wyoming, on the Bear River Drainage. This was a straight-line movement of 91 km.

Subadult M11 moved northeast to Main Canyon, Wasatch County, Utah, in late fall of 1987. His radio went into slow beat mode and he appeared to have denned in that area. In March 1988 we discovered him dead near Main Creek. Utah State Wildlife Resources law enforcement officers determined that he had been shot, probably in late fall of the preceding year. He had moved approximately 30 km.

Male 45, another subadult born on the study area, was killed by an ADC agent during a sheep depredation incident. This was on the Right Fork of the White River, Wasatch County, a straight line distance movement of 75 km.

The dispersal patterns demonstrated by our subadult bears (Figure 3) have been documented in other areas. Rogers (1987) observed that as young bears grew, males dispersed and females increased their range sizes near their birth sites. Several authors (Dobson 1982, Waser and Jones 1983, Holekamp and Sherman 1989) have studied male-biased dispersal patterns common among promiscuous species. Evolutionarily, the dispersal of males and fidelity to natal areas by females has resulted in low incidences of inbreeding. Several of our males dispersed to areas greater than 100 km from their birth place, and dispersal movements of this distance should (based on average home range sizes) result in minimal inbreeding of a black bear population. Long-distance moves from capture sites were not observed in west-central Colorado by Beck (1991).

C. Clyde (UDWR) initially hypothesized that bears in our study used an established breeding ground, and observations made during the study support his hypothesis. In black bear populations with large home ranges, common breeding areas would minimize energy costs to males and females seeking appropriate mates. Females with cubs most likely avoided the shared area in order to protect their cubs from potential predation by adult male bears (LeCount 1988).

Habitat Selection and Food Preferences

Food availability strongly influenced habitat selection, and foraging activity has been documented as a primary factor in habitat selection by bears in other areas (Rogers 1987a, Mack 1988, Unsworth *et al*. 1989). Similarly, LeCount *et al*. (1984) observed Arizona black bears using habitats that provided abundant grass in early phenological development.

Rogers (1987a) and Raine and Kansas (1989) also reported the use of ants during summer as a transitional food between spring greens and fall fruits. Acorn crops failed every year of the HC-DF study.

Bear association with fruit-bearing shrubs increased during fall (Table 8). Serviceberry occurred on 42.9% of the microsites sampled during fall. Chokecherry occurred on 46.6% of the fall plots. Fruits comprised approximately 30.0% of the bears' fall diets (Figure 6). Bear association with oak brush at microsites was low (28.6%). Acorn crops failed every year of the study.

Microsites selected by females supported a greater diversity of vegetation than did sites chosen by males. Shannon's index values of diversity were 3.8 for females and 2.9 for males (Ludwig and Reynolds 1988). Habitat types used during spring significantly departed from expected in relation to habitat availability ($\underline{x}^2 = 36.0$, $\underline{a} = 0.05$).Bears selected strongly for aspen stands and moderately for conifer; "other" habitat types were avoided. Summer movements produced similar results. Aspen and conifers were selected for, the "other" types were selected against, departing significantly from expected ($\underline{x}^2 = 97.3$, $\underline{a} = 0.05$). The remaining types were selected for according to availability. Fall movements were more random and habitat types were thus used in greater proportion to their availability. A significant departure from expected ($\underline{x}^2$ = 27.4, $\underline{a}$ = 0.05) was still detected in fall locations resulting from the avoidance of “other” habitats (Table 4).

Conifers provided important cover for bears during all seasons. In addition to the 105 microsites analyzed, 4 bed sites were analyzed. All bed sites occurred in conifer dominated stands.

Front Pad Width

Front pad widths were measured on 21 adults (4 years or older). There were 10 males and 11 females. All female front pads had a width of 115 mm or less (Table 21). The range was 100 mm – 115 mm with an average of 103 mm. Male front pad widths ranged from 110 mm – 134 mm with an average of 121 mm. This data for the most part finds that adult females have a front pad width less than 114 mm (4.5”) and can be used as a tool to separate male from female tracks (Black and Auger, 2004). This information is given in the 2006 Utah Black Bear Proclamation, Utah Division of Wildlife Resources. It states: “There is an 86 percent chance that a black bear track with a front paw width larger or equal to 4.5 inches will be a male bear.” Our findings on the HC-DFSA concur with this statement.

Table 21. Front foot pad sizes (mm) of Utah black bears (HC-DFSA) and Colorado bears[a].

	Front pad width	
	Colorado	Utah (HC-DFSA)
Adult Male	127-143	121-134
Adult Female	109-120	103-115

[a] Data from Beck 1991

Winter Ecology

Some male black bears began denning activity as early as mid October (n=2). Two others did not den until late November to early December. Exit dates ranged from mid March to mid April. Days spent in the dens ranged from 87-185 with the mean 133 days.

Females (n=22) consistently denned early to mid October regardless of reproductive status. Number of days spent at or near their dens ranged from 155-216 days with the mean 189 days. Females with newly born cubs averaged 195 days at or near their dens. Females with yearlings spent 180 days and those with no offspring spent 172 days on average.

Twenty females' dens were located and checked for the presence of cubs. Eleven were found to have COY present. Single cubs were found in four (36%) dens, twins were born in seven (55%) dens, and one (9%) set of triplets occupied the last den entered in 1994. The average litter size was calculated at 1.72 cubs per litter. This compares favorably to most western states' litter average sizes (Table 22).

Sex ratio of cubs in dens has been shown to be 1:1 in many studies (Reynolds and Beecham 1980, Massopust 1984, LeCount 1986, Alt 1989, Hellgren and Vaughn 1989, Elowe and Dodge 1989, Kolenosky 1990, Schwartz and Franzmann 1991).

The ratio of males to females COY was found to be 2.16 M:1 F. This imbalance in favor of males was also found by Kolenosky and Strahearn (1987).

Cub weights in dens show some differences throughout the United States (Table 23). These vary from 1.7 kg in Maine and on the East Tavaputs Plateau of Eastern Utah. Minnesota reports 2.6 kg for their state. Cub weights for the HC-DFSA were 3.3 kg. This was the highest reported weight for 7 studies (Table 3). During our study we entered nine dens. Five contained single cubs. Four of these were male cubs (80%), and one was a female (20%). Four dens (44%)

were found to have twins; two with 2 males, one with 2 females, and one with a male and female cub. One set of triplets was encountered but no weights were obtained. The mother and her offspring ran as we approached the den on a very warm spring day in 1993.

Single males averaged 3.57 kg (n=4) and a single female averaged 4.08 kg (n=1). All single cubs of both sexes averaged 3.67 kg.

Females born in twin litters weighed an average of 2.95 kg (n=3) and males averaged 3.20 kg. The average weight of all cubs born in twin litters was 3.11 kg. Cubs born in single litters weighed 0.56 kg more than those born in twin litters.

Den weights were obtained from 13 COY (March 1 – April 9). Males averaged 3.37 kg and females 3.23 kg (Table 24).

Four females aged using cementum annuli analysis were found to be three years old at time of breeding. Two produced single cubs at four years of age. Females 7 and 32 had a female and male cub respectively. Females 3 and 23 gave birth to twin males.

Table 22. Comparison of average litter size for black bears reported by geographic regions across North America. (From Beck 1991)

Reference	State	Litter size	Data Source[a]
EAST			
Carney 1985	VA	2.0	D
Hugie 1982	ME	2.1	D
Hellgren & Vaughn 1989	NC	2.1	S
Ellowe & Dodge 1989	ME	2.4	D
Eiler et al. 1989	TN	2.6	D
Alt 1989	PA	3.0	D
Avg.		2.4	
GREAT LAKES			
Erickson et al. 1964	MI	2.3	S
Kohn 1982	WI	2.4	S
Kolensky 1990	ON, CAN	2.4	D
Rogers 1987	MN	2.5	D
Massopust 1984	WI	3.0	D
Avg.		2.5	
WEST			
Rohlman 1989	ID	1.5	S
Koch 1983	CA	1.6	S
Beecham 1980	ID	1.7	D
Piekielek & Burton 1975	CA	1.7	S
Jonkel & Cowan 1971	MT	1.7	S
LeCount 1986	AZ	1.9	D
Keav 1990	CA	1.9	S
Beck 1991	CO	2.0	D
HC-DFSA THIS STUDY	UT	1.7	D
Avg.		1.7	
ALASKA			
Schwartz & Franzmann 1991	AK	2.1	D
Schwartz & Franzmann 1991	AK	2.3	D
Avg.		2.2	

[a]S = Data from summer counts, D = Data from den counts

Table 23. Comparison of March weights of both sexes of COY

State	Wt (kg)	N
Maine	1.7	19
Tenn.	2.1	28
Wiscon.	2.3	unk.
Minn.	2.6	75
Colo.	2.3	42
Utah E. Tavaputs Plateau	1.7	49
HC-DFSA THIS STUDY	3.3	12

Table 24. Weight of black bear cubs (kg) in maternal dens by sex and date, HC-DFSA, 1986-1994.

	Average weight			
Week	Males	N	Females	n
Mar. 1-8	3.18	1		
Mar. 9-16	3.80	4		
Mar. 17-24	2.98	4	2.95	3
Apr. 9-16			4.08	1
Total mean wt.	3.37	9	3.23	4

Den Characteristics

During the ten years of this study twenty-two dens were visited. Five males and seventeen females were found. All were located using radio telemetry. Aerial telemetry was used to locate the den area as close as possible. Snowmobiles got us as close to the dens as possible and most were located using snowshoes. Cubs born the current year were found in 11 dens. Three containing mothers and yearling cubs and three females had no cubs with them.

Males used rock dens (2), tree dens (1), and dug or found dens (2) already dug (Table 25). One lone yearling went back to the den he was born in to winter after his mother and brother went their separate ways during his second summer.

Females used 12 dug dens (71%) and 5 rock dens (29%) to winter in (Table 25). An older female, F2, denned in a rock cavern behind a waterfall. As the winter got colder, a wall of ice almost sealed her in. In January, an unseasonably warm spell thawed the ice shield and it appeared they got wet. They moved about a mile away and dug a north facing den under roots of Gambel oak (Querques gamebelii). The warm weather and light snow cover made this possible and could have saved both bears from death.

Table 25. Characteristics of Male and Female den on the HC-DF study area 1985-1994.

	No.	Age	Type	Veg Cover Type	Elevation Meters	Aspect	Young Present
Males	4	4#	Dug	Conifer	2940	NE	
	8	Subadult	Dug	Conifer	2680	NE	
	26	Adult	Rock	Open	2800	N	
	26	Adult	Rock	Open	2900	N	
Females	2	8#	Rock	Conifer	2050	E	m yrlg
	2	8#	Dug	Oak	2300	N	m yrlg
	3	4#	Dug	Conifer	2350	E	COY mm
	3	6	Rock	Open	2450	SE	COY ff
	7	4#	Rock	Open	2300	W	COY f
	7	8#	Rock	Open	2300	W	COY f
	14	Adult	Rock	Oak	2425	E	COY m
	14	Adult	Dug	Conifer	2800	NE	no cubs
	23	4#	Dug	Conifer	2455	NW	COY ff
	25	Adult	Dug	Oak	2500	NE	COY mm
	30	Adult	Dug	Mtn. Bush	2100	NW	f yrlg
	31	Adult	Dug	Oak	2100	NW	f yrlg
	33	Subadult	Tree	Conifer	2650	E	
	36	Adult	Dug	Oak	2300	NE	no cubs
	36	Adult	Dug	Conifer	2450	NW	no cubs
	39	Adult	Dug	Oak	2200	E	1 yrlg
	43	Adult	Dug	Mtn. Bush	1850	N	COY mmf
	32	4#	Dug	Conifer	2050	N	COY m

Age determined by cementum annuli analysis.

Summery of characteristics of black bear den sites, HC-DF, 1985-1994.

		Percent		No. Den Type (%)			Elevation (M)	Aspect			
Cover Type	# of Dens	M	F	Rock Cavern	Dug Den	Tree Den	Median Range	N	E	S	W
Conifer	10	40	60	2	7	1	2795 (2650-2940)	60	30	0	10
Oak	5	0	100	0	5	0	2280 (2100-2500)	40	40	0	20
Mtn. Bush	3	0	100	1	2	0	2085 (1850-2300)	100	0	0	0
Open Rock	4	50	50	4	0	0	2550 (2050-2900)	50	50	0	0

Sizes of black bear home ranges vary across their geographical distribution. On the Hobble Creek-Diamond Fork study, adult male home ranges ($\underline{x}$ = 112.7km^2) were approximately three times as large as adult female home ranges ($\underline{x}$ = 41.4 km^2) In Pennsylvania, Alt et al. (1980) found black bears using large home ranges. Male homes ranges averaged 173 km^2 while females occupied smaller ranges of 41 km^2. At the other extreme, Lindzey and Meslow (1977) observed bears using very small home ranges on Long Island in southwest Washington. Males used 5 km^2 and females 2 km^2.

Bears in our study had comparatively large home ranges (Table 19). Jonkel and Cowan (1971), Armstrup and Beecham (1976), and LeCount (1980) suggested that the quality, quantity, and distribution of food set minimums on size of bears' (particularly females) home ranges as influenced by climate and topography. Mack (1988) indicated that large home range size is indicative of low quality habitats. Although bears in our study had large home ranges and they appeared to obtain adequate nutrition. This is evident by the large average size obtained by all age and sex classes of bears in our study (Table 20). One 3 year-old female produced 2 cubs in her first litter which suggests that her nutritional needs were being met. According to Rogers (1976), early reproduction in bears ($\underline{x} \leq$ 4 years) is an indication of higher levels of nutrition. Bears we studied were effective predators (Figure 6). Perhaps the inclusion of animal prey in their diets required bears in our study to occupy large areas.

Bears of the same sex used nearly exclusive home ranges. Common areas were shared at peripheries. However, considerable home range overlap occurred between males and females in our study (Figure 2). Similar results have been reported by others (Armstrup and Beecham 1976, Lindzey and Meslow 1977, LeCount et al. 1984). Rogers (1987) indicated that males attempt to maximize reproductive success by breeding with as many females as possible. This strategy would account for the high degree of overlap and large home ranges of males.

Near the center of the study area, three adult females (2F, 3F, and 7F) shared a common area on the peripheries of their home ranges. In 1986, all three bears were trapped at this site during breeding season. Female 2F was accompanied by a cub. An adult male (6M) was also captured at that time. The following year (1987) female 2F returned and was probably bred. Females 3F and 7F were not observed in the area. In 1988 females 3F and 7F were recaptured in the shared area. Both had yearlings with them. Female 2F had a cub and avoided this area. Both females 3F and 7F produced cubs in 1989. Neither female returned to the shared area during the following breeding season. It was anticipated that female 2F would return in 1989 to use the common area, but she died the previous fall. No females were captured in the shared zone that year. Rogers (1987) observed similar responses among bears in Minnesota where the bears returned to approximately the same area for mating each year.

Mortality

Known causes of black bear mortality during this study have been identified as depredation kills by government and private persons, illegal hunting (poaching), legal hunting harvest, accidents, and natural mortality. The cause of death was determined for 17 (35%) of the 48 marked individuals on the HC-DFSA. The following reasons were found for those of which a cause of mortality could be determined: there were 5 illegal kills (10%), 3 by legal hunting (6%), 3 by natural mortality (6%), 1 in an accident (hit by a car) (2%), and 5 bears killed because of livestock depredation (10%). Thirty one of the bears had unknown fates.

The first bear was trapped, marked, and instrumented on 5 June 1985. It was an adult male, and it was found dead five months later. The incident was reported by a deer hunter who observed another hunter shoot the bear and walk away upon seeing the ear tags and radio. The radio collar was retrieved the next day.

A history of black bear hunting is found in Table 26. This table shows that the Utah Fish and Game Commission (UFGC) made the black bear a game species and closed the harvest season during the eleven days of the October 1967 general deer season. This happened on 15 February. Even though the HC-DFSA had a 354-day open season, between 1967 and 1977 no bears were reported taken. In the fall of 1978-1985 this area was closed to bear hunting by order of the UFGC. In 1986-1995 it was open to hunting by an allotted number of permits. During this time four legal hunting kills were checked in at the Utah Division of Wildlife Resources offices. Two were resident adult females we had trapped and radioed on the HC-DFSA. In addition, two males marked on the study area were legally harvested on other units.

Twenty-nine percent of the known causes of bear mortality on the HC-DFSA are human-caused.

Table 26. History of black bear depredation removal and hunter harvest on the Hobble Creek – Diamond Fork Study Area. Feb. 15, 1967 black bear was made a game animal. Season closed during the 11 day general deer hunt.

Year	State-wide Sport Harvest	Depredation Harvest	Total State Harvest	HC-DF Sport Harvest	
1967	15	12	27	0	Open to sport hunting except during 11 day general deer hunt.
1968	12	9	21	0	
1969	22	14	36	0	
1969-70	3	13	16	0	
1970	9	18	27	0	
1971	17	16	33	0	
1972	19	7	26	0	
1973	25	0	25	0	
1974	29	9	28	0	
1975	22	2	24	0	
10 yr average	17.3	10.0	26.3	0	
1976	10	7	17	0	
1977	26	6	32	0	
1978	40	10	50	0	Closed to hunting.
1978	26	5	31	0	
1980	26	6	32	0	
1981	39	4	43	0	
1982	38	6	44	0	
1983	18	9	27	0	
1984	26	6	32	0	
1985	29	10	39	0	
10 yr average	27.8	6.9	34.7	0	
1986	72	6	72	1	Legal hunts begin again on study area.
1987	44	25	69	0	
1988	69	28	97	0	
1989	97	10	107	0	
1990*	22	16	38	0	
1991	35	15	50	1	
1992	32	25	57	1	
1993	35	12	47	0	
1994	42	20	62	1	
1995	53	34	87	0	Dep & ADC 4
10 yr average	70.5@ 50.1 42.5#	19.1	68.6	0.4	

* Limited entry hunting began statewide and continued during this study.
@ Before limited entry hunting began.
# After limited entry hunting.
From: Pederson and Bates 1989 and Blackwell and Evans 1995.

Management Implications

Several habitat types were important, and special attention needs to be given these types to maintain their integrity. Although conifer areas accounted for a small percentage (8.3%) of the total vegetation, they were heavily utilized, as they provided both bedding and security cover. In timber management planning, Unsworth *et al*. (1989) suggested that timber stands should be maintained on north-facing aspects and along streams and roads to provide bedding and hiding cover for black bears. We found timbered areas on north-facing slopes used as den sites, which demonstrated their value to black bears. The few conifer stands that exist on the Hobble-Creek Diamond Fork management unit need to be protected. Additional plantings on appropriate sites could enhance bear distribution.

Aspen habitats provided important foraging areas. Selective cutting of conifer trees encroaching upon aspen stands could be used to encourage aspen regeneration for maintaining stand integrity and security cover. Abundant spring bear foods can be assured in this habitat type by keeping livestock off these ranges until mid to late June. Livestock should be well-distributed and moved frequently to prevent damage to existing vegetation, especially along and near riparian zones. The conversion of sheep grazing to cattle use would reduce livestock depredation and the need for lethal control actions by livestock producers or government wildlife specialists. This would reduce sheep-bear conflicts as a cause of bear mortality.

Another source of bear mortality is human-bear conflicts usually over human food or garbage. Every effort should be made to reduce or eliminate these conflicts. An awareness campaign should be instituted to inform the public that they are hiking, camping and entering black bear country. Signs should be posted at all entrances to the area informing visitors of the proper ways to bear proof their camp and avoid these conflicts. In places where vehicles are not present to lock food in bear proof food boxes should be provided. Where garbage is collected for later removal, bear proof dumpsters should be installed and dumped several times a week during periods of high temperatures and peak visitor use.

Because of black bear low overall reproductive rates, management practices should lean toward the conservative, and protection of the female segment of the black bear population is key. All management and hunting regulations should be evaluated for their effects on the total population but female black bear survival and protection should be the highest management priority.

ACKNOWLEDGEMENTS

Our appreciation is extended to all who so generously devoted time, money and materials to make this project a success. Funding and support for this project were provided by the Utah Division of Wildlife Resources, Brigham Young University, U.S. Forest Service (Uinta National Forest), U.S. Fish and Wildlife Service, Utah Big Game Hound Association, Lynn M. Sorensen, Timpanogos Archers Club, and W.W. Clyde Construction Company. We also express our appreciation to S. Bagley, D. Braun, K.D. Bunnell, E. Fleming, D. Graff, D. “Bud” and W.L. Hutchings, D. Mann, D. Mitchell, G. Ogborn, G.T. O’Neal, S. Phillips, D. L. Shirley, R. Radant, J. L. Diamond, C. L. Clyde, Dr. B. Welch, E. Bird, and B. Blackwell for their help and support on this project. To pilots C. Morris and L.S. Watlrath, trappers B. Nusink, T.E. Vecchiolli, and T. Weight, we express gratitude for their help. We especially thank Earl Sutherland for his field savvy and hard work on this study. C.R. McLaughlin, A.L. Pederson and W.E. James provided much appreciated comments that contributed to improving this paper. We express our appreciation to Brenda Bushell and Christa Shields for their skill and patience with our many manuscript changes and revisions.

Literature Cited

Ackermen, B.B., F. A. Leban, M.D. Samuel, and E. O. Garton. 1989. *User's Manual for Program Home Range*. Second Edition. Technical Report 15, Forestry, Wildlife and Range Experiment Station, Univ. of Idaho, Moscow, Idaho. 79 pp.

Alt, G. L., G. J. Matula, F.W. Alt, and J.S. Lindzey. 1980. *Dynamics of home range and movements of black bears in northeastern Pennsylvania.* Int. Conf. Bear Res. And Manage. 4:131-136.

Armstrup, S. C. and J. Beecham. 1976. *Activity patterns of radio-collared black bears in Idaho*. J. Wildl. Manage. 40(2):340-348.

Bates , S. B. 1991. *Seasonal food habits of central Utah black bears.* M.S. Thesis, Brigham Young Univ., Provo, Utah.

Beck, T. D. I. 1991. *Black bears of west-central Colorado.* Technical Publication. No. 39. Colorado Division of Wildlife. 86 pp.

Beecham, J.J. and J. Rohlman. 1994. A shadow in the forest: Idaho's black bear. University of Idaho Press, Moscow, Id.

Beringer, J. J., S. G. Seibert and M. R. Pelton. 1989. *The impact of roads on movement ecology of black bears in Pisgah National Forest, North Carolina.* Int. Conf. Bear Res. And Manage., Victoria, British Columbia, Canada.

Black, H.L. and J. Auger. 2004. Black bears of Utah's East Tavaputs Plateau. Final Report: December 2004. Brigham Young University, Provo, Utah.

Blackwell, B.H., and G. Evans. 1995. Utah Black Bear Harvest. Utah Division of Wildlife Resources. Publ. Number 95-1.

Bowen, W. D. 1982. *Home range and spatial organization of coyotes in Jasper National Park, Alberta*. J. Wildl. Manage. 46(1):201-216.

Collins, G.H., S.D. Kovach, and M.T. Hinkes. 2005. Home range and movements of female brown bears in southwestern Alaska. Ursus 16 (2) 181-189.

Conover, W. J. 1980. *Practical Nonparametric Statistics*. Second ed. John Wiley & Sons, New York, N.Y. 493 pp.

Daubenmire's, R. 1959. *A canopy-coverage method of vegetational analysis.* Northwest. Sci. 30:43-64.

Dobson, F. S. 1982. *Competition for mates and predominant juvenile dispersal in mammals. Anim. Behav. 30:1183-92.*

Elowe, K.D. and W. E. Dodge. 1989. *Factors affecting black bear reproductive success and cub survival.* Journal of Wildlife Management 53: 962-968.

Garshelis, D. L. and M. R. Pelton. 1980. *Activity of black bears in the Great Smokey Mountains National Park*. J. Mammal. 61(1):8-19.

____________,____________. 1981. Movements of black bears in the Great Smoky Mountains National Park. Journal of Wildlife Management 45: 912-925.

Graber, D. M. and M. White. 1983. *Black bear food habits in Yosemite National Park.* Int. Conf. Bear Res. And Manage. 5:1-10.

Green, J. S. and J. T. Flinders. 1981. *Diets of sympatric red foxes and coyotes in southeastern Idaho.* Great Basin Nat. 41:251-254.

Greer, S. Q. 1987. *Home range, habitat use and foot habits of black bears in south-central Montana. M.S. Thesis, Mont. State Univ., Bozeman. 91 pp.*

Grenfell and Brody, W. E. Jr. and A. J. Brody. 1983. *The seasonal foods of black bears in Tahoe National Forest, California.* Cal. Fish and Game. 69:132-150.

Gysel, L. W. and L. J. Lyon. 1980. *Habitat analysis and evaluation.* Pages 305-328 *in* S. D. Schemnitz, ed. Wildlife Management Techniques Manual. The Wildl. Soc.

Hatler, D. F. 1972. *Food habits of black bears in interior Alaska*. Can. Field Nat. 86:17-31.

Hellgren, E. C. and M. R.Vaughn. 1989. *Denning ecology of black bear in a southeastern wetland.* Journal of Wildlife Management 53: 347-353.

Holekamp, K. E. and P. W. Sherman. 1989. *Why male ground squirrels disperse.* Am. Sci. 77:232-39.

Hortsman, L. P. and J. R. Gunson. 1982. *Black bear predation on livestock in Alberta.* Wildl. Soc. Bull. 10:34-39.

Jonkel, C. J. and I. McT. Cowan. 1971. *The black bear in the spruce-fir forest*. Wildl. Monogr. 27. 57 pp.

Kolenosky, G. B. and S.M. Strahearn. 1987. *Winter denning of black bears in east-central Ontario.* Int. Conference Bear Research and Management. 7:305-316.

----------. 1990. *Reproductive biology of black bears in east-central Ontario.* Int. Conference Black Bear Research and Management. 8:385-392.

LeCount, A.L. 1980. *Some aspects of black bear ecology in the Arizona chaparral.* Int. Conf. Bear Res. And Manage. 4:175-79.

----------, R. H. Smith, and J. R. Wegge. 1984. *Black bear habitat requirements of central Arizona. Ariz. Game and Fish Dep. 49 pp.*

----------, 1986. *Black bear field guide.* Ariz.Game and Fish Dep. Phoenix. 130 pp.

----------, 1988. *Causes of black bear cub mortality.* Unpubl. paper. Ariz. Game and Fish Dep., Phoenix. 24 pp.

Lienbach, J. 1987. *The Hobble Creek story.* U.S. For. Serv., Uinta Natl. For, Spanish Fork, Utah. 25 pp.

Lindzey, F. G. and E. C. Meslow. 1977. *Home range and habitat use by black bears in southwestern Washington*. J. Wildl. Manage. 41:413-425.

Ludwig, J. A. and J. F. Reynolds. 1988. *Statistical Ecology.* First ed. John Wiley & Sons, New York, N.Y. 337 pp.

Mack, J. A. 1988. *Ecology of black bears on the Beartooth face, south-central Montana.* M.S. Thesis, Mont. State Univ., Bozeman. 119 pp.

Manville, A. M. 1983. *Human impact on the black bear in Michigan's lower peninsula.* Int. Conf. Bear Res. And Manage. 5:20-33.

Massopust, J. L. 1984. *Black bear homing tendencies, response to being chased by hunting dogs, reproductive biology, denning behavior, home range, diet, movements, and habitat use in northern Wisconsin.* Univ. Wisconsin. Stevens Point. 168 pp.

Mollohan, C. M. 1987. *Characteristics of adult female black bear daybeds in northern Arizona.* International Conference on Bear Research Management. 7:145-149.

O'Neal, G. T., J. T. Flinders and W.P. Clary. 1987. *Behavioral ecology of the Nevada kit fox (Vulpes macrotis nevadensis) on a managed desert rangeland.* Pages 443-481 *in* H. H. Genoways, ed. Current Mammalogy, Vol. 1. Plenum Publ. Co., N.Y.

Onorato, D.P., E.C. Hellgren, F.S. Mitchell and J.R. Skiles, Jr. 2003. Home range and habitat use of American black bears on a desert montane island in Texas. Ursus 14 (2) 120-129.

Pederson, J.C., and J.W. Bates. 1989. Utah Black Bear Harvest. Utah Division of Wildlife Resources. Publ. Number 89-4.

Pelton, M. R. 1982. *Black bear.* Pages 504-514 *in* J. A. Chapman and G. A. Feldhamer, eds. Wild Mammals of North America. Johns Hopkins Univ. Press, Baltimore, Md.

Raine, R. M. and J. L. Kansas. 1989. *Black bear seasonal food habits and use of elevation in Banff National Park, Alberta.* Unpublished Paper. Calgary, Alberta, Canada.

Reynolds, D. G. and J. Beecham. 1980. *Home range activities and reproduction of black bears in west-central Idaho.* Pages 403-409 *in* C. J. Martinka and K. L. McArthur, eds. Bears – Their biology and management. U.S. Gov. Print Off. Wash. D.C.

Richardson, W. S. 1991. *Macro- and microhabitat selection by black bears in Southeastern Utah.* M.S. Thesis, Brigham Young University, Provo, Utah.

Robinson, W.L. and E. G. Bolen. 1984. *Wildlife ecology and management.* McMillan Pub. Co., New York, N.Y. 478 pp.

Rogers, L. L. 1987. *Factors influencing dispersal in the black bear*. Pages 75-84 in B. D. Chepko-sade and Z. T. Halpin, eds. Mammalian dispersal patterns. Univ. of Chicago Press, Ill.

----------, 1987a. *Effect of food supply and kinship on social behavior, movements, and population growth of black bears in northeastern Minnesota.* Wildl. Monogr. 97.

Schwartz, C. C. and A. W. Franzmann. 1991. *Interrelationship of black bear to Moose and Forest succession in Northern Coniferous Forest. Wildl. Monogr. 113. 52 pp.*

Tenney, L.A. 1996. Home range in two Utah black bear populations. M.S. Thesis. Brigham Young University, Provo, UT.

Tisch, E. K. 1961. *Seasonal food habita of the black bear in the Whitefish Range of northwestern Montana.* M.S.

Unsworth, J. W., J. J. Beecham, and L. R. Irby. 1989. *Female black bear habitat use in west-central Idago*. J. Wildl. Manage. 30:411-14.

Waser, P. M. and W. T. Jones. 1983. *Natal philopatry among solitary mammals.* Quarterly Review of Biol. 58:355-90.

Willey, C. H. 1974. *Aging of black bear from first premolar tooth sections.* Journal of Wildlife Management. 38:97-100.

Wilkinson, L. 1988. *SYSTAT: The System for Statistics*. Evanston, Ill., SYSTAT Inc.

Young, B. F. and R. L. Ruff. 1982. *Population dynamics and movements of black bears in east central Alberta.* J. Wildl. Manage. 46:845-60.

Young, D. D. and J. J. Beecham. 1986. *Black bear habitat use at Priest Lake, Idaho.* Int. Conf. Bear Res. Manage. 6:73-80.

Zager, P. E. 1980. *The influence of logging and wildlife on grizzly bear habitat in northwestern Montana.* Ph.D. Thesis, Univ. of Mont., Missoula. 131 pp.

We extend thanks to the following organizations for providing funding for this publication:

Brigham Young University

Department of Plant and Wildlife Sciences

The Mule Deer Foundation

Miles Moretti President/CEO

Utah Division of Wildlife Resources

Conservation Outreach Section

Wildlife Section